RAINER KARLSCH

Hitlers Bombe

DVA

When the first atomic bomb fell on Hiroshima on August 6, 1945, the leading German nuclear physicists around Werner Heisenberg and Carl Friedrich von Weizsäcker commented on the event: They would never have built such a bomb for Hitler and therefore made sure in 1942 that corresponding projects had been delayed in.

Sixty years later, the Berlin historian Rainer Karlsch has reconstructed the truth. Research groups that are still little known today went their own way in reactor construction and worked on a thermonuclear mini-bomb. Despite successful attempts, it was foreseeable that the "miracle weapon" that Hitler was talking about more and more from the summer of 1944 could no longer be used decisively in the war.

At the end of March 1945, Himmler and Speer stopped the project, which was headed by the SS. The author's most explosive finds include contemporary research reports, construction plans, aerial photographs, diaries of the scientists involved, as well as Russian and American espionage reports. Last but not least, the evidence is supported by physical expertise, soil analyzes and measurements.

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Rainer Karlsch, born 1957, Dr. oec, doctorate in 1988 at the Humboldt University in Berlin, then employed at the chair for economic and social history at the Humboldt University, the Historical Commission in Berlin and the Freie Universität Berlin. Together with the TV journalist Heiko Petermann, he researched the history of German nuclear research intensively for four years. They were supported by international historians, physicists and radiochemists.

Main publications: Paid alone? The reparations of the SBZ/GDR 1945 - 53, 1993 (Stinnes Price); Uranium Secrets, 2002; Oil Factor. The mineral oil industry in Germany 1859-1974, 2003

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This book unveils a sensation:

German scientists tested under the supervision of the SS

1944/45 nuclear bombs on Rügen and in Thuringia.

Several hundred prisoners of war and prisoners lost their

lives.

In addition to evidence for the nuclear weapons tests, the Berlin historian Rainer Karlsch also found a draft

for a plutonium bomb patent from 1941 and discovered the first functional

ning German nuclear reactor.

“Hitler had a bomb. German scientists developed

a nuclear weapon during World War II. These are the breathtaking results of the impressive book

by Rainer Karlsch, the result of in-depth, often laborious research

work. Karlsch's book leaves decades of research on science under

National Socialism behind. This work is important for understanding the

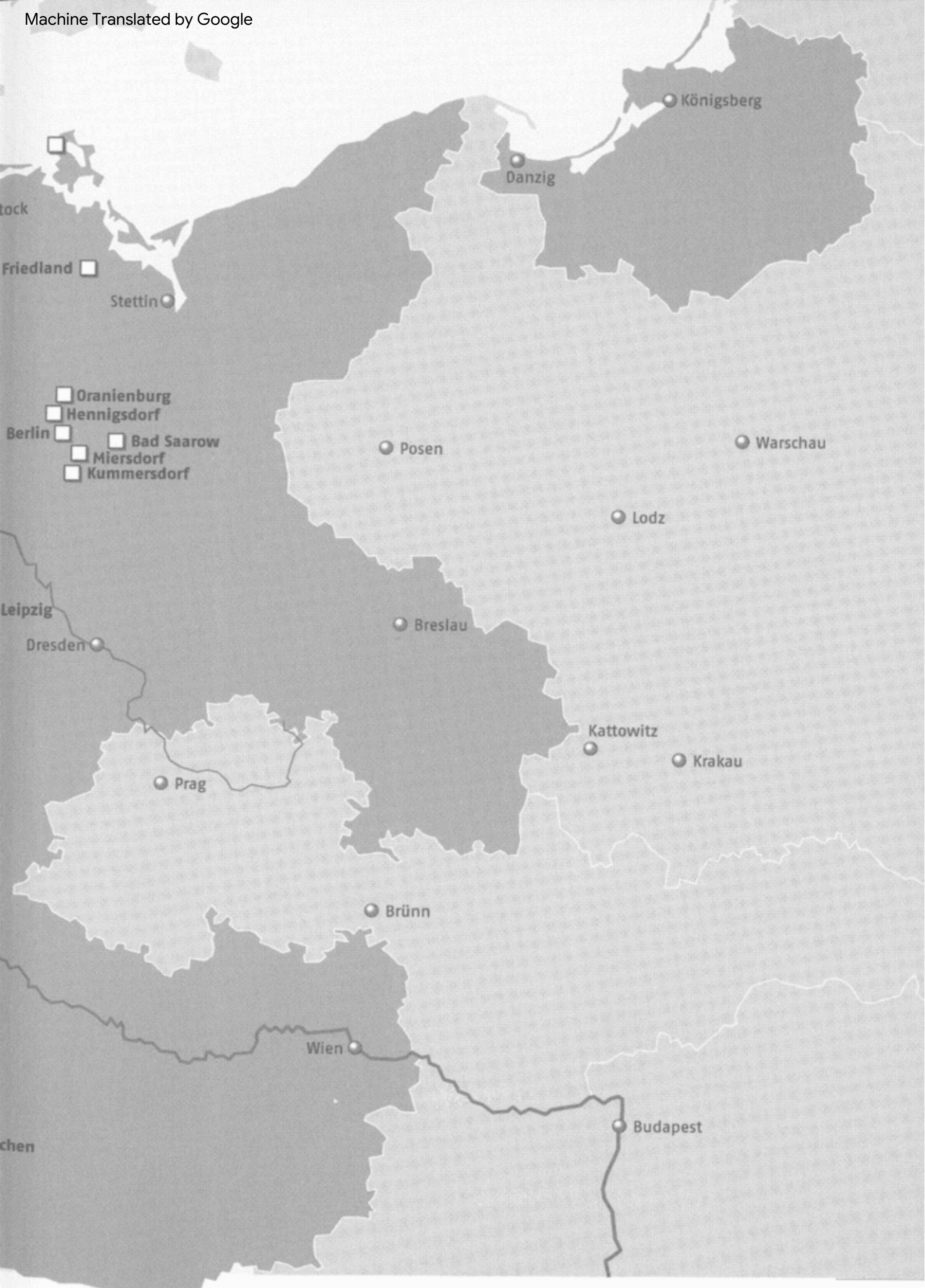
society under Hitler - and the potential danger emanating from nuclear

weapons today.«

Professor Mark Walker, author of the book The uranium machine

DVA

Deutsches Reich 1938
inklusive Österreich und Sudetenland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RAINER KARLSCH

Hitler's bomb

The Secret History of
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Part Five: AFTERNOBS

"History is something that perhaps can't really be written until it's all gone so long that no one lives who has any actual interest in what it was like should."

Carl Friedrich von Weizsacker

foreword

Was there a German atomic bomb? Until now, international research had assumed that the German nuclear physicists were far behind the Americans in the race for the bomb.
New archival finds and physical analyzes presented to the public for the first time in this book necessitate a reassessment.

Hitler's bomb, a tactical nuclear weapon whose destructive potential was far below that of the two American atomic bombs, was successfully tested several times shortly before the end of the war. Their action almost added another terrible chapter to the Second World War.

Our thinking is shaped by images. Photographs and film recordings of mushroom clouds are among the most powerful images that will forever be associated with the history of the 20th century. The destructive fireball, the huge cloud of dust, the desolate emptiness in the center of the explosion, the severe damage visible from miles away - all of this has been deeply engraved in the historical memory of the people. No one who has seen the footage of the human remains melted and dissolved into nothing will ever forget the horror they emanate. Hiroshima has become one of the central metaphors for the past century.

Since the American atomic bombs were dropped on Hiroshima and Nagasaki on August 6 and 9, 1945, an atomic explosion has been equated with the greatest destructive power imaginable. As great as people's abhorrence of atomic bombs has been since then, we know very little about how these weapons work and the dangers they pose. This is ensured not least by the governments of those states that are in possession of nuclear weapons.
In addition to the five permanent members of the UN Security Council, USA, Russia, China, Great Britain and France, today these include Israel, India, Pakistan and North Korea. However, numerous

che other states about the theoretical knowledge for the production of nuclear weapons, which increases the secrecy even more.

For example, there are completely wrong views about the duration and intensity of the effects of radiation after a nuclear explosion. Many believe that an explosion area has been contaminated for decades and can no longer be entered without endangering life and limb. In fact, the radioactive contamination in the explosion area falls drastically hours after the event.1 A few weeks after the atomic bomb was dropped on Hiroshima, American scientists only managed with difficulty to detect increased radioactivity. If there were no memorials in the cities, an ignorant visitor today would not even suspect what tragedies happened there in August 1945.

The often used image of the "nuclear desert" is emotionally highly effective, but does not reflect reality. Because I too initially orientated myself on the pictures of Hiroshima, I dismissed the first references to a German atomic bomb test in the spring of 1945 as nonsense. But then the curiosity of the researcher awoke.
She was at the beginning of this book.

In the second half of the 1990s, I dealt extensively with uranium ore mining in the former GDR and published about it.2 As a result, my name was frequently mentioned in the relevant literature, and I was regularly asked about this or that detail. In May 2001 I received a short letter from the television journalist Heiko Petermann. He is investigating the question of whether atomic bombs were tested in the German Reich shortly before the end of the Second World War and wanted to know how many tons of uranium the Germans had available at the time. I felt duped, and my reply was correspondingly short and dismissive.

Heiko Petermann then presented me with reports from contemporary witnesses, all of which concluded that a small atomic bomb had been tested in Thuringia in early March 1945. The witnesses quoted from conversations with some of the scientists responsible for the experiment, described a test that had been carried out successfully and reported the deaths of several hundred people as a result of this experiment.

ment of assigned prisoners of war and inmates as a result of a violent explosion. A witness reportedly heard the last words of a dying prisoner of war: "Fire, many dead instantly, off the ground, simply gone, many badly burned, many blind."3 All this sounded very wild and unconclusive . The leading elite of the Third Reich had repeatedly spoken in dark allusions about a mysterious wonder weapon.

In an interview with the Romanian head of state Antonescu in August 1944, Hitler referred to a bomb that had such a powerful effect that it fell "within a radius of three to four kilometers from the Ein All human life would be destroyed at the point of impact."4 His armaments minister, Albert Speer, went even further in a one-on-one meeting in January 1945 and declared: "We only have to get through one more year and then we will have won the war." There is "There's a new explosive," said Speer, pointing to a box of matches lying on the table: "A nuclear explosive the size of this box is capable of destroying the whole of New York."

At the beginning of March 1945, when American troops had already crossed the Rhine and the Red Army was only 60 kilometers from Berlin on the Oder, Reichsfuhrer SS Heinrich Himmler, in a conversation with his personal physician, pinned his hopes on an atomic bomb: "We haven't used our last wonder weapon yet. While the V1 and V2 are effective weapons, our ultimate silver bullet will have effects beyond imagination. One or two shots and cities like New York or London will disappear from the face of the earth.'6 There were a number of similar statements from Hitler's inner circle. Insofar as contemporary historical research dealt with it at all, it interpreted it as propaganda or wishful thinking, far from any reality.

The state of historical research seemed clear to me. The failure of the German nuclear project can be read in any better history book:7 According to this, from mid-1939 there was the not particularly effective Uranium Association, a research association headed by the Army Weapons Office and the Reich Research Council. As it was the German chemist Otto Hahn

However, the Allies had to assume that German scientists were working hard to use atomic energy for military purposes. The fear of a German bomb was a powerful impetus for their own project. Initially, only scant and inaccurate information was available in London, Washington and Moscow about the status of German nuclear research. The military head of the American nuclear project, General Leslie R. Groves, therefore put together a special group in 1943 under the code name “Also”. She was to find out how far the Germans had gotten with their efforts.8 The Dutch physicist Samuel A. Goudsmit was appointed scientific director.9 He not only had the necessary qualifications, but also knew many of the most important ones from his student days in Göttingen German physicist personally.

Goudsmit's men made an important discovery in November 1944 at the Reich University in Strasbourg. Research documents captured there showed that the Germans were still debating the construction of a »uranium machine«. After all, they didn't even have a functioning reactor with which they could have produced fissile materials for building a bomb. Goudsmit later wrote: 'There was no doubt. The available material proved unequivocally that the Germans neither had an atomic bomb nor could they construct it in any practicable form [...] After Strasbourg it was just an adventure.«10 This assessment was also shared by the British-American Intelligence Committee at the end of 1944. 11

After the end of the fighting in Europe, clearing up German nuclear secrets was no longer a priority for the Americans. They concentrated on shielding the Manhattan Project, since the war against Japan was not yet over. They wanted to avoid a public discussion about uranium research because they were trying to keep the Soviet Union away from nuclear secrecy. For these reasons, ten of the most important German scientists were brought to Great Britain in the summer of 1945 and interned at the Farm Hall country estate. Their conversations were monitored around the clock. When these logs

When they were finally released in the early 1990s, the last remaining doubts seemed to have been dispelled.12 The German scientists had failed with their project, and the Americans had won the »war of the physicists«.

As the only nuclear power, Americans found themselves in a new dominant role immediately after the war, which contributed to their disdain for the scientific achievements of other countries. In 1947, under the impression of the crimes of the Nazi regime and full of anger at the German elite, Goudsmit drew a sometimes grossly distorted picture of German nuclear research. He cited the neglect of basic research and above all the mismanagement of the uranium project as reasons for the failure of the German physicists. He compared science under a totalitarian regime with science in a democracy and concluded that only in a democracy is there the intellectual freedom that allows science to develop fully. The thesis seemed plausible, but could not explain why the Third Reich, like the Soviet Union, was at the forefront of technical progress in selected areas of armaments research. Goudsmit's main blow was for Nobel Prize winner Werner Heisenberg, whom he saw as the scientific brains behind the German project. Heisenberg and his collaborators wanted to build an atomic bomb, but ultimately failed because of their scientific errors and complacency.

The German scientists, who were attacked in their scientific honor, did not want to put up with this. Some reacted with articles in specialist journals in which they attempted to correct their role in research into the Third Reich.13 Others limited themselves to presenting their research achievements, but avoided any reference to the circumstances of the time.14 All in all, these accounts convey the Impression that only basic research was carried out at the physical institutes in the German Reich during the war. This was the German contribution to the creation of legends.

The first book written by an outsider appeared in 1956 and caused a sensation: Brighter than a Thousand Suns.15 Author Robert Jungk relied mainly on his interviews

with leading scientists of the Uranium Association. He advocated the thesis that a circle of convinced opponents of the regime among German physicists had steered the uranium project on harmless paths and thus prevented Hitler from obtaining an atomic bomb. Ten years later, the British author David Irving took up the subject and painted a picture of a dramatic race between the Germans and the Allies to develop the first atomic bomb.16 Initially, the Germans held important trump cards, but by the end of 1942 they were held by the Americans been overtaken. While the German project was progressing at a snail's pace, the Americans had created a massive nuclear complex with the Manhattan Project.

The American science historian Mark Walker set new standards in the early 1990s with his books and Articles.17 They were based primarily on the evaluation of the »German Reports«, more than 390 research reports written by members of the Uranium Association between 1939 and 1945.18 With the »My thos of the German atomic bomb«. According to Walker, the Germans had by no means decided not to build the terrible weapon.
In his opinion, the researchers around Heisenberg had not gotten far enough to even have to make a decision for or against building bombs. In the foreword to the German edition of Walker's book The Uranium Machine, Robert Jungk withdrew his thesis that the leading German physicists

displayed passive resistance.19 With the book Heisenberg's War, the American science journalist Thomas Powers sparked the discussion about the passive resistance of German physicists again a few years later.20 In his view, Heisenberg had quite deliberately maneuvered the German project into a »storage room«. This point of view sparked fierce opposition.21 The controversy continued and was fueled by Wolfgang Menge's television film The End of Innocence and Michael Frayn's stage play Copenhagen.22 The moral question was always at the forefront of the debate responsibility of the scientist. Hardly any other historical example can be used to illustrate the pros and cons of "value-free science

In these debates, which lasted more than half a century, hardly anyone was interested in the fact that there were other research groups besides Heisenberg and the Uranium Association. It was left to outsiders like the British physicist Philip Henshall to point out that the Germans probably got further than they arrived.23 Henshall's thesis of a secret nuclear cooperation between the German Reich and the Japanese Empire remained unproven, but threw it exciting new questions. Speculation ran rampant, and in the end a few die-hards wanted to know that the bombs used on Hiroshima and Nagasaki were not American bombs but German bombs.24 In conspiracy theories of this kind, one claim follows another none can really be corroborated.25 Fortunately, the scientist has numerous means of verification at his disposal. He should be able to separate the wheat from the chaff.

"Whatever isn't in the files didn't happen either." With this subtle hint, superiors usually describe their wish to record as little as possible in writing of an upcoming campaign. Especially in times of war, many of the most sensitive documents are destroyed. In war, the truth dies first. Secrecy and censorship prevail. This applied to a very special degree to the nuclear projects. In Washington and Moscow, some of the most important documents are still blocked for historical research.

Historians work systematically with the existing sources. They therefore tend to prefer to ignore poorly documented events, which can narrow their perspective. This was exactly the case when researching the history of German nuclear research. It was narrowed down to the Uranium Association because the Uranium Association left behind most of the documents. It was not taken into account that not only the army and the Reich Research Council practiced nuclear physics, but also the Navy and Air Force, the Reichspost and several large companies. Their activities were only marginally considered, if at all. To make matters worse, as a result of the division deci

development of the German Reich, the documents of many scientific institutions and authorities were scattered to the four winds. For example, Soviet troops in Berlin captured the documents of the Kaiser Wilhelm Institute (KWI) for Physics, numerous files from the Army Ordnance Office and other military offices, complete company archives and much more. Until the end of the Soviet Union in 1991, there was no chance to look at these files.

The search for these documents was of central importance for this book. Thanks to the help of Russian friends, the head of the research program “History of the Kaiser Wilhelm Society under National Socialism”, Carola Sachse, and the support of the President’s Commission of the Max Planck Society, the inventory of the KWI for Physics and others stored in Russia could be moved Documents will be made accessible for historical research for the first time in the years 2002 to 2004.

As far as the high degree of secrecy by the Germans themselves is concerned, Hitler issued a basic order on this back in January 1940.26 The more the war situation deteriorated, the more suspicious he became.27 His pilot Hans Baur reported that Hitler had Suspected that there was a spy in his immediate vicinity. "At the end of 1944 there was an atmosphere of mutual suspicion in the Führer's headquarters."28 Hitler used to conduct particularly explosive discussions in private. This also applied to atomic research. We will never know, therefore, how accurate his knowledge of the progress of the uranium project was. Larger groups only spoke in very general terms about the "wonder weapons". If the conversation did take a concrete turn, it was no longer allowed to be recorded.29 Even those responsible for

nuclear physics research only had decisive conversations in private and did not record sensitive appointments in their work calendars. This is briefly explained using the example of Walther Gerlach, the last head of the Uranium Association. His secretary, Giesela Guderian, kept an accurate appointment book and typed all his correspondence.

However, as soon as a guest came to Gerlach to report on the latest research results, she was sent out of the room.30 Particularly important meetings were not allowed to be included in the schedule .

to be entered. That concerned, for example, March 22, 1945. For this day, Gerlach's diary only contains notes about a surprising trip from Thuringia to Berlin.31 However, the decisive appointment with the Reichsleiter of the NSDSP, Martin Bormann, is missing in his diary. Bormann only found out that Gerlach had been summoned to report because four weeks later the Americans stole documents from Gerlach, which included a handwritten note about the meeting.

The executives of the companies directly involved in the uranium project were only informed about the aspect that affected their own company. A director of Degussa wrote about the activities of a subsidiary in October 1941: "Auer sells special metal directly to the Wehrmacht [...] What the Wehrmacht needs the metal for is not known."32 Only six months later was the Degussa Board clear that the term »special metal« meant uranium. Often enough, employees in a particular department did not even know that their work was related to the uranium project.

Shortly before the end of the war, many secret documents were more or less systematically destroyed. The gaps in the files of the research departments of the Navy, the Air Force, the SS and the Reichspost are particularly large. Things don't look much better in the non-public sector. In many company archives of companies involved in nuclear research in one way or another – including IG Farben, Siemens, AEG and the Auergesellschaft – only fragments of these activities can be found.

When I first read the testimonies of the March 1945 tests, I was reluctant to respond. Did the witnesses actually speak of a nuclear explosion? And how should one check that? Such reports could only be the beginning of a scientifically sound argument.33 The authenticity of the reports was soon beyond doubt. They were created in the early 1960s as part of a survey carried out by newspaper editors, apprentices and students with the approval of the SED district leadership in Arnstadt, during which more than 50 contemporary witnesses were interviewed. The results were summarized in

a 362-page report, only part of which has survived. The journalists Gerhardt Remdt and Erich Wendel from the Ilmenauer Kreiszeitung played a central role in the research at the time. They had come across traces of an SS construction staff, for which, according to a contemporary witness, the then Federal President Heinrich Lübke is said to have worked.34 Their investigations thus suddenly came under the scrutiny of the Ministry for State Security (MfS). Such reports came at just the right time for the head of the agitation commission at the Central Committee of the SED, Albert Norden. For some time he had incriminating material collected against the Federal President in order to stage a "Lübke affair."35

For the two editors, references in other directions were much more important.36 They suspected a connection between the construction of the last Führer headquarters near Ohrdruf, the shipment of valuable goods to the Thuringian area and the production of new weapons. When they thought they had come across traces of German nuclear research, their company was stopped "from above" in January 1967.37 The district office of the Ministry for State Security took over further research.38 The Stasi received the most important statement from master plumber Gerhard Rundnagel . However, his story of two small atomic bombs in a safe belonging to a research group of the Army Weapons Office (HWA) that had been outsourced to Stadtilm sounded so improbable that the Stasi officers in Arnstadt could not relate to it.39 There was no political interest in pursuing th

Could clues be found in German, Russian or American archives? After two years of searching involving numerous colleagues and friends, chance came to my rescue. Heiko Petermann came across an article by the Russian physicist Pavel V. Oleynikov from the Institute for Technical Physics at the Nuclear Research Center in Chelyabinsk.40 Oleynikov dealt with the role of German scientists in the Soviet nuclear project and also relied on letters from Georgij Flerov that had just been released , one of the most important Soviet physicists of the war and post-war years.41 In May 1945, Flerov had flown to Germany to look for traces of nuclear tests. Although Fle-

rov's letters did not reveal whether his mission had been successful, but for me this was the first solid proof that the reports of the contemporary witnesses from the 1960s had a core of truth.

With the help of friends in Moscow, I managed to acquire the volumes on the history of the Soviet nuclear project, edited in a very small edition in 2002 by employees of the Kurchatov Institute.42 It contains a letter from Igor Kurchatov, the head of the Soviet nuclear project, to Stalin, March 30, 1945. The letter refers to a nuclear test in Germany. The Red Army's military intelligence had heard about it a few days earlier and alerted the Kremlin. An examination showed that these documents were genuine. But the authenticity of the documents was far from proof that such a test had actually taken place. Perhaps the Germans had only wanted to deceive the Soviet leadership in the last weeks of the war? Single sources, no matter how high-calibre, would never suffice for conclusive evidence.

If the Soviets knew about the test, then possibly the Americans and British did too. The corresponding research in the National Archives in Washington, in the Public Record Office in London and Kew and in many other places did not provide direct evidence, but shed light on many interesting aspects of the German armaments industry, including nuclear physics.

Parallel to the archive work, Heiko Petermann and I arranged for the suspected test areas to be sampled and for soil samples to be taken and analyzed by several institutes specializing in detecting the smallest amounts of radioactivity. Physicists from the Justus Liebig University in Gießen, led by the physicist Professor Arthur Scharmann, the radiochemist Professor Reinhard Brandt from the Philipps University in Marburg and scientists from the Physikalisch-Technische Bundesanstalt Braunschweig, led by the experimental physicist Professor Uwe Keyser, were involved . If nuclear events had actually taken place on the suspected areas, then artificial elements such as cesium 137 and cobalt 60 must be found in the soil samples well above the usual local values. This proof succeeded and supports the main theses of the book.

Of course, there was the question of whether the presence of these isotopes could not have other causes and could be explained, for example, by a later Soviet nuclear test or the Chernobyl reactor accident. Now the Soviet Union, if only for reasons of secrecy from the NATO countries, did not carry out any nuclear weapons tests outside of its national territory. Between 1949 and 1990, the Soviet Union carried out a total of 715 nuclear detonations on its territory - and only here - in which a total of 969 individual nuclear charges were detonated.43 There was also no demonstrable detonation of tactical nuclear weapons for maneuver purposes in the territory of the GDR. The aftermath of the devastating Chernobyl reactor accident in 1986 has been studied by scientists around the world. In the process, “physical fingerprints” were also taken, with the help of which it can be determined whether increased values in a certain area are due to the reactor accident in Ukraine or not. Such a cause could definitely be ruled out for the study areas in Thuringia.

In the end, the extremely difficult question remained as to what exactly was being tested there in the spring of 1945. Igor Kurchatov had already tried in vain to answer this question at the end of March 1945. When the spy report was presented to him for comment, he could not make sense of why a nuclear explosion should have destroyed only a very small area, five to six hundred meters in radius. According to his calculations, a uranium bomb should have caused much more destruction. However, the information Kurchatov had was not precise enough to put him on the right track. Only 60 years later and thanks to a wealth of additional information was it possible to draw conclusions and find an explanation.

The critical mass for a uranium bomb made from highly enriched U235 is around 50 kilograms, for a plutonium bomb around ten kilograms. Bombs of this type were detonated over Hiroshima and Nagasaki on August 6 and 9, completely destroying areas of several square kilometers and killing tens of thousands of people. At the German nuclear

bombs, it definitely cannot have been such bombs. German scientists did not have access to sufficient amounts of highly enriched uranium or plutonium.

Theoretically, it would have been possible to use uranium enriched to at least ten percent as a nuclear explosive. In this case, however, hundreds of kilograms would have been required. And even if the German physicists could have reduced the critical mass by around half by using a reflector, very large quantities of fissile materials would still have been required, and the German Reich did not have these.

After reviewing all the physical measurement results again, we delved into the research reports on so-called shaped charge processes with the help of experts. In isolated technical articles from the 1950s, the construction of atomic shaped charges was described in astonishing detail. The specialist articles also revealed highly explosive personal connections that went back to the research groups of the war years: scientists from the Navy, the Army and the Air Force already had the knowledge for the construction of tactical nuclear weapons based on the shaped charge principle in 1944. The last decisive pieces of evidence were found in the estate of the head of the research department of the Army Weapons Office, Professor Erich Schumann, which was thought to have be

The real sensation of Schumann's estate is a manuscript that he wrote in 1949 in consultation with former employees.44 In it he describes, among other things, the research on nuclear fusion that he had begun and developed the concept for building a hydrogen bomb. In plain language, this means that three and four years respectively, before the first American and Soviet hydrogen bombs were tested, the head of nuclear research at the Army Weapons Office described their general construction principles and mode of operation fairly precisely. Because colleagues he asked for advice urgently advised against it, Schumann withdrew the manuscript that had already been contractually intended for publication.45 Not more than a handful of scientists knew about the attempts by the Army Weapons Office to release nuclear energy by fusing light elements. Schumann wrote about this in 1949: "If the planned and prepared in Germany towards the end of the

If nothing has been reported about the previous experiments, the reason for this is that only a few scientists were informed and the files had to be destroyed in April 1945.«46

German scientists did not have a weapon comparable to the American and Soviet hydrogen bombs of the 1950s. However, they knew the general outlines of how one works and were able to use the shaped charge technology they had perfected to trigger initial nuclear reactions. Whether these were fusion or fission reactions, or a combination of both processes, remains to be explored and debated.

Since only small amounts of fusion and fissile materials reacted, the effectiveness of the German atomic bomb remained limited. As a result of their research, the German scientists had developed, if one uses modern terms, a tactical nuclear weapon.

Until the spring of 1945, the smallest circle around Hitler hoped to be able to use the new bomb for a surprise attack. Under the direction of the SS, preparations were made to equip carrier rockets with these bombs. As late as April 1945, the Reichsleiter of the NSDAP, Martin Bormann, announced that the use of the atomic bomb was imminent. That was pure perseverance propaganda. Even if some of the new bombs had still been used, as was temporarily planned, the course of the war would not have been decisive.

Not all questions related to German nuclear weapons research up to 1945 could be finally clarified. The political, technical and military background to the development of the German atomic bomb must be further elucidated by contemporary historiography. Individual studies should succeed in making the networks, which are difficult to understand, even more transparent. What is certain is that there never was a master plan for the development of a German atomic bomb. What is also certain, however, is that at the end of the development process, a tactical nuclear weapon was successfully tested. After weighing all the arguments, I think it is right to hand over to the public the evidence that Heiko Petermann and I have gathered over years of puzzle work on the 60th anniversary of the end of the war.

FIRST PART

The German Uranium Project

1. The Uranium Club

The discovery of nuclear fission and its consequences

Shortly before Christmas 1938, Professor Otto Hahn and his assistant Fritz Strassmann completed an unusual series of experiments at the Kaiser Wilhelm Institute for Chemistry (KWI) in Berlin. They had intended to create radium by bombarding uranium with neutrons, but instead of knocking a few particles out of the uranium, they had split the uranium atoms in two.

The world's best radiochemist at the time, Otto Hahn, could not believe it at first. He wrote to his former colleague Lise Meitner, who had had to flee Germany, to ask her opinion.

Like all leading atomic physicists of her time, Lise Meitner was convinced up to that day that an atomic nucleus could not possibly be split. Breaking apart the extremely compact nucleus held together by massive forces with a single neutron would be like throwing a pebble at a boulder in the hope that it would split it in two.

Meitner discussed the problem with her nephew, the physicist Otto Frisch. Finally, they came to talk about the “droplet model” of the atomic nucleus introduced by Niels Bohr, which states that heavy nuclei behave almost like drops of liquid, i.e. they can be stretched and compressed like a water-filled balloon. According to Bohr's theory, each of these "droplets" must also have surface tension, which means that the atomic nucleus remains stable despite its mobility.

Two opposing forces exist in the nucleus: the repulsive effect of the protons and the attractive effect of the strong nuclear force. Both forces normally cancel each other out, which means that the liquid droplet remains in a constant state of equilibrium between explosion and implosion. Meitner and Frisch now came up with the idea that in a particularly heavy core like this

of the uranium due to the increasing charge, the surface tension should be reduced overall. Analogously, one can imagine the water-filled balloon, the skin of which becomes thinner the larger and heavier the balloon is. In this state, a nudge with a finger (or with a single neutron) may be enough to burst the atomic nucleus.

The riddle of nuclear fission was thus solved. Meitner and Frisch came to another conclusion: theoretically, the two fragments of uranium together had to be a lot lighter than the original atom, namely exactly one-fifth the mass of a proton. It was immediately clear to the two of them where this mass had gone: part of the core had been converted into energy, into a great deal of energy. According to this, a single atom generated about 200 million electron volts (MeV) during its fission – an enormous amount.

Hahn and Strassmann published the results of their test series on January 6, 1939. The sensational findings spread like wildfire in the world community of physicists.

The most fascinating moment of the novel nuclear reaction was the large energy release. But Hahn had overlooked the important question of whether neutrons were released in this process.

In those days, nuclear physicists hoped or feared that there would be no avalanche effect. Independently of one another, however, several physicists then confirmed the assumption that nuclear fission would produce additional neutrons. A chain reaction was therefore possible.

When the Parisian physicist Jean Frederic Joliot-Curie also confirmed the chain reaction in the journal »Nature« on April 22, 1939, this led to lively scientific discussions and official reactions in Germany. Independently of one another, several physicists drew the attention of their superiors to the economic and military applications of nuclear fission. Wilhelm Hanle, a young physicist who had just moved to Göttingen from the University of Jena, finally got the ball rolling. He was supposed to give a lecture on nuclear fission at a colloquium: "After mine

I used to go to the library shortly beforehand. I came across a paper by Joliot, Halban, and Kowarski on the emission of multiple fast neutrons in the fission of uranium by a slow neutron. I quickly combined: The use of nuclear energy has always been a dream of nuclear physicists. It was now within the realm of possibility.« Hanle gave a lecture on

»Energy generation from a uranium fission machine«. He stated that this should be built from a combination of uranium and heavy water or graphite. He expected approval from his mentor, Professor Georg Joos, »but the opposite was the case. During the lecture I noticed how his face changed. I knew the signs. They read 'Storm'. At the end, Joos abruptly broke off the discussion, took me into his room and heaped reproaches on me: 'How could you do something like that! That is of enormous importance. This is not just a scientific idea. This gives the country that succeeds in implementing it a huge technical advantage. You can't just bring something like that out into the open in a colloquium.«1 Hanle and Joos wrote a letter to Reich Minister of Education Bernhard Rust in which they explained the possible consequences of nuclear energy. The idea of a nuclear explosive was one of them.

On April 24, 1939, just two days after Joliot-Curie's publication, Professor Paul Harteck of the University of Hamburg and his assistant Wilhelm Groth pointed out to the War Department that the development of nuclear explosives was possible: "The country that first [of nuclear fission] has an unrivaled superiority over the others.«2 As Harteck explained many years later, he hoped that his initiative would get additional research funds for his institute.3 This was probably not his only motive. After all, he had already been working intensively with the Army Weapons Office (HWA) for two years, to which his letter was forwarded. In June 1939, Nikolaus Riehl, head of the research department of the Berlin Auer Society, which specialized in the processing of uranium and thorium compounds, drew the HWA's attention to the possibilities of nuclear fiss

The Reich Minister of Education was the quickest to react. He forwarded the letter from Joos and Hanle to the Reich Research Council, and there it ended up on the desk of Abraham Esau. He was soon to play an important, albeit unfortunate, role in the German uranium project.5 Professor of technical physics at the University of Jena since 1925, Esau had been appointed President of the Physikalisch-Technische Reichsanstalt (PTR) in Berlin in 1939. With the rank of Councilor of State, Esau belonged to various bodies, particularly those relevant to military research. At the beginning of the war he was at the zenith of his power. He was at the interface between science, the Wehrmacht and the armaments industry. The Reich Research Council made him head of the physics department.

When Esau received the letter from Göttingen and was entrusted by the Reich Ministry of Education with organizing a conference on questions of nuclear physics, he saw an opportunity to upgrade his field and bring himself to the fore. On April 29, 1939, Esau called a secret meeting. Of course, Otto Hahn was at the top of the invitation list. However, he apologized and sent Josef Mattauch to represent his institute. Also present were: Walther Bothe, director at the KWI for medical research in Heidelberg, Hans Geiger, professor at the TH Berlin, the Leipzig professor for experimental physics Gerhard Hoffmann as well as Joos and Hanle from Göttingen Colleague of Esau, Otto Hahn,

because he had published his discovery, and expressed the confidence that before the outbreak of war a new type of bomb could be developed and tested on the grounds of the army research institute in Kummersdorf, or even better on the open sea.7

Mattauch dismissed Dames' attack, saying it would take at least five years, if not fifty, to build a uranium machine or a bomb. The discussion then revolved around the question of whether it was even possible to construct a uranium reactor. Esau suggested bringing together the country's most important nuclear physicists into a research group under his direction. Someone from the group named this group

»Uranium Association«. The designation was anything but appropriate, but it was retained anyway.

For the upcoming experiments, the scientists needed uranium compounds in larger quantities than were previously available to them. Esau therefore appealed to the Reich Ministry of Economics for the confiscation of all stocks and had the export of all uranium compounds banned.

The military takes over

The discovery of nuclear fission naturally had consequences for the military, initially at its central office for the development and manufacture of weapons, equipment and ammunition, the Army Ordnance Office.8 The HWA research center proceeded with all projects from the basic principle, the existing structures, to do so belonged to universities, non-university research institutions and companies, to use and control them in their own interest. Only research that could not be “outsourced” due to its military significance was located in the HWA itself.

Head of the HWA's research department from 1934 was Professor Erich Schumann.9 In a short time he had risen to become a multi-functionary. From 1929 he headed the department for acoustics at the Physics Institute of Berlin University and taught experimental and theoretical physics.10 In 1934 he was appointed director of the newly founded Second Physics Institute. He was particularly interested in explosives physics. When dealing with the university circles, Schumann always tried to emphasize the fact that he had the backing of the Wehrmacht. His classification as Ministerial dirigent roughly corresponded to the rank of major general in the army.
Quite a few of those he spoke to remembered him as a "general," impressive in uniform and with his vivacious and dynamic demeanor.11 Opinions among contemporaries differed widely on Schumann's qualities

as a scientific organizer. Some saw him as a capable scientist and great promoter of warfare research and explosives physics, others named him

him a charlatan who put himself at the service of windy projects. His enthusiasm for military music earned him the ridicule of seasoned physicists; they knew that he had dealt with the timbre of the oboe in his habilitation thesis.12 But to reduce Schumann to the role of a vain power man would be to underestimate his scientific competence and organizational talent.

Schumann's ability to pull the strings was in demand when it came to occupying the field of nuclear physics. The occasion was a meeting called by his superior, General Karl Becker, in mid-June 1939. Becker had read an article by Siegfried Flügge, who worked at Otto Hahn's institute. In it Flügge calculated: "One cubic meter of uranium oxide is sufficient to generate the energy required to lift one cubic kilometer of water (total weight ten trillion kilograms) 27 kilometers."13 These were dimensions that Becker wanted to put up for discussion. Erich Schumann, whose head of the physics department, Dr. Walter Basche, and the Chief of Staff of the HWA, Colonel Dr. Wager. Becker also invited Max Planck, the President of the Kaiser Wilhelm Society (KWG), Abraham Esau and the Vice Dean of the Defense Technology Faculty at TH Berlin, Professor Hans Winkhaus. Planck answered evasively when asked about the prospects of generating atomic energy, but recommended that nuclear physics research be promoted. Perhaps one would soon be able to give more precise answers. Schumann reacted on June 15, 1939 by founding a department for atomic physics in the HWA.14 Kurt Diebner was entrusted with the task, and Diebner's immediate superior was Walter Basche.

In photos from the war, Kurt Diebner looks like a high school senior, small and slender, with short, already thinning hair and narrow, round glasses. He appeared reserved and modest. He wasn't a good speaker. Perhaps his appearance also contributed a little to the fact that he was underestimated throughout his life. Stimulated by Heinz Pose, who was the same age, Diebner turned to nuclear physics. He led a meager student life at the Universities of Innsbruck and Halle because his parents did not have the means to support him. The dream of social advancement

One of the driving forces behind his actions was to join the well-to-do and materially secure caste of university teachers.15 His academic career was aided by membership in a powerful association. Diebner became an active member of the "Halloren", one of the oldest student associations in Germany. He took part in the inevitable mensurations and got his throws.

Diebner received his doctorate in 1931 from the University of Halle. The work showed that his strengths lay in the field of experimental physics. Shortly after he had acquired his doctorate, he first switched to the PTR and in 1934 to the HWA. There he worked on the initial detonation of explosives with the help of radioactive rays.16

Schumann's and Diebner's strengths lay less in the theoretical area and all the more in the organization of research projects. One of Diebner's closest associates: "Both of them were probably particularly interested in the uranium project, in order to achieve special advantages for themselves, increase their reputation and their official position, for which a new, important project of this kind offered the best prospects."17 The new department was to be set up in the army research institute in Kummersdorf.

When Hitler triggered World War II with the invasion of Poland on September 1, 1939, there were two competing groups in the field of uranium research in Germany.

One, called the Uranium Association, was subordinate to the Reich Ministry of Education, the other to the Army Weapons Office. Whoever was in charge under the changed conditions should decide quickly. Schumann instructed Basche and Diebner to convene a secret conference to discuss the original request. The necessary personnel for setting up a nuclear physics research group could now be recruited by being drafted into the Wehrmacht. For the scientists, this was an opportunity to avoid being deployed at the front and to continue their research.18 This is how many members of the Uranium Association did their military service in nuclear research. On the other hand, working for the HWA meant being subject to strict confidentiality regulations, which made scientific exchange more difficult.

Erich Bagge also received a call-up order from the HWA. The young physicist worked as an assistant to Werner Heisenberg and had only received his doctorate the year before. He should report to Erich Schumann and Kurt Diebner. A good fifty years later he wrote down his memories of this meeting, at the beginning of which he asked Diebner: "What is this actually about?" Diebner is said to have replied with a smile: "It's about the atomic bomb!"19 Did Bagge follow the conversation like this has reproduced accurately for a long time is questionable. Diebner had probably not yet used the term atomic bomb in the fall of 1939. The atmosphere of that time reflects Bagge's memory very well.

Diebner explained his tasks to Bagge: »We have to organize a meeting with nuclear physicists here in this building for September 16, which I'm sure you all know. You should read Flügge's work on the production of energy from atomic nuclei very carefully, that's why the point is to prepare an agenda for the meeting and to propose a list of gentlemen to be invited However, there should be no more than ten participants.«20 Who should Bagge suggest? He named Otto Hahn, Hans Geiger, Werner Heisenberg, Paul Harteck, Georg Stetter, Gerhard Hoffmann and Walther Bothe. The last two were involved in the construction of particle accelerators. They were also joined by Josef Mattauch and Siegfried Flügge, both of whom worked at Hahn's institute. When Diebner read the list of names, he stopped short at Heisenberg's name. He did not see why one should involve a theoretical physicist. Experimental physicists were primarily in demand here. So Heisenberg was initially left out.

Of the experimental physicists, however, only Paul Harteck and Walther Bothe were ultimately to play outstanding roles in the Uranium Association. Bothe had made several great discoveries as head of the laboratory for radioactivity at the PTR.21 From 1934 he headed the Institute for Physics at the Kaiser Wilhelm Institute for Medical Research in Heidelberg. The physiochemist Paul Harteck was also highly regarded.22 Together with Ernest Rutherford and Mark Oliphant, he carried out the first experiment on nuclear fusion in Cambridge in 1932. In November 1935 he had a professorship in the chemistry department of the Hamburg Univ

position started. Harteck was an enthusiastic experimenter and lived entirely for science. He did not join the NSDAP or any of its branches. Nevertheless, he came to terms with the new balance of power.23 From 1937 Harteck was an adviser to the HWA on chemical explosives.

The first meeting of the Uranium Association headed by the HWA was opened by Walter Basche on September 16, 1939: The German foreign intelligence service had learned that uranium research was being carried out in other countries. One does not know whether a uranium project is really feasible and thorough research is needed to clarify this question. If the answer is positive, the HWA must deal intensively with the development of the new energy source. Otherwise you know that the enemy also has this energy source.

During the discussion, Harteck proposed a spatial separation of the uranium and the moderator to trigger chain reactions. It was known that neutrons with low kinetic energy preferentially initiate fission. During the fission process, however, they are formed as fast particles. They must therefore be slowed down outside of the uranium by a moderator. Above all, Harteck pleaded for the immediate start of the work.

But there were dissenting voices. If one wanted to obtain the uranium isotope U235, which is particularly suitable for fission, this would require an unimaginable effort, said Otto Hahn. Other concerns included the ability to obtain sufficient quantities of certain substances, personnel issues, and a lack of knowledge of atomic nuclei. The discussion threatened to tip over. Then Hans Geiger stood up: "I have to say that if there is even the slightest chance that this new source of energy exists, then we must start work on its development, and we must do so immediately!"24 That was the deciding factor. Research tasks were distributed, and at the end Basche asked whether there were any suggestions for the participation of other gentlemen in the meetings of the uranium association. Bagge then suggested that Heisenberg should also be involved in the future. This was accepted.

Research scattered across the Reich

The Uranium Association did not have a fixed structure. The KWI for Physics in Berlin, which had been in the service of the Army Weapons Office since January 1940, acted as the lead institute. It was the most modern institute in Germany and had a cold laboratory, several X-ray systems and a high-voltage system.25 After the founding of the Uranium Association, the variety of work areas was restricted without concentrating exclusively on nuclear physics. Unlike later in the USA and the Soviet Union, no closed nuclear research complex was built in Germany. The work on the uranium project was initially carried out by about one hundred scientists at nineteen different institutes. The distances made communication difficult and slowed down work on the project.

In July 1940, planning began for the construction of a wooden laboratory building on the property of the KWI for Biology and Virus Research, right next to the KWI for Physics. The laboratory was given the code name »Virushaus«. The laboratory was ready for occupancy at the beginning of October 1940, behind which a pit almost two meters deep had been lined. It served to hold a reactor vessel and could be filled with water. Looking back, it may come as a surprise that the reactor tests were to be carried out in the heart of Berlin. It was no different in the USA. The first experimental reactor was set up there on a sports field in Chicago. Not enough was known to assess the dangers.

In addition to the KWI for Physics, the neighboring KWI for Chemistry was also intensively involved in research for the Uranium Association under the direction of Otto Hahn. This institute traditionally worked closely with the HWA. Opinions differ as to the direct military use of the work at Hahn's institute.26 Hahn, who certainly had no sympathy for the Nazis and supported racially persecuted colleagues, later claimed for himself and his institute that during the war only conducted basic research ben and otherwise the uranium project to have stood away. However, the research reports from his institute show that this is not true. It is correct that the KWI for Chemistry is not directly involved in the construction of the

search reactors was involved. However, it is also clear that the prerequisite for any reactor operation is the most precise knowledge possible of the subsequent products in order to be able to maintain a controlled chain reaction. This preparatory work was done by Hahn's employees.

The contribution of the Physikalisch-Technische Reichsanstalt to the uranium project was definitely important, albeit less noticed.27 In the course of its reorganization, a department for atomic physics and physical chemistry (Department V) was established in 1939, headed by Hermann Beuthe.28 His department had eight laboratories that dealt with basic research, the construction of measuring instruments and, most importantly, the development of neutron sources.

Compared to the two Berlin Kaiser Wilhelm Institutes and the PTR, only supplementary work was carried out at other scientific institutions in the capital. Leipzig University played a central role in uranium research until the end of 1942. The fact that three institutes in Leipzig worked largely independently of one another for the Uranium Association was typical of the poor coordination of the entire project. Heisenberg prepared several reactor experiments with the Döpel couple. Completely independently of this, the physiochemist Karl-Friedrich Bonhoeffer dealt with the problem of heavy water, and the experimental physicist Gerhard Hoffmann struggled to build a cyclotron.

With a cyclotron, particles can be accelerated to energy that can be used in nuclear physics. In doing so, they repeatedly run through circular paths, into which they are forced by a magnetic field, and gain energy with each run. After reaching their final energy, the particles are directed towards a target.
When colliding with the target matter, nuclear reactions take place, the products of which, such as gamma rays or nuclear fragments, are measured with detectors. This data allows conclusions to be drawn about the structure of the nuclei.29 Since there was personal enmity

between Döpel and Hoffmann, it was impossible to reach an understanding about the common concern. When Heisenberg moved to Berlin in the summer of 1942 and Hoffmann did not make much headway with the cyclotron project, Leipzig lost its importance for the uranium project.

The situation was different with the KWI for medical research in Heidelberg. From start to finish, the working group headed by Walther Bothe was almost exclusively entrusted with research work for the uranium project. Despite some tensions, this was done in close cooperation with the KWI for Physics in Berlin.

While Bothe and Heisenberg were preparing joint reactor tests, a small Hamburg research group was entrusted with work on isotope separation and new processes for the production of heavy water. The leader of this group, Paul Harteck, was one of the most brilliant minds in the Uranium Association. As a notorious optimist, he was brimming with ideas and entrepreneurial spirit. After the war, quite a few of his comrades-in-arms suspected that the German uranium project would have been more successful under his leadership.

Austrian physicists held a certain special position.30 Only the 2nd Physics Institute of the University of Vienna, headed by Georg Stetter, was officially involved in the work of the Uranium Association. Willibald Jentschke, who worked for Stetter, later said that the work in Vienna was not controlled at all by the Uranium Association: »The [senior employees of the HWA] never came to Austria [...] But we had a loose organizational connection .«31 A neutron institute was founded at the University of Vienna in 1942 specifically for the uranium project, and Stetter became its director. It was one of the nuclear physics facilities with the best personnel and material in the German sphere of influence.32 Individual research tasks related to the uranium project were also carried out at the universities of Innsbruck and Graz.33

There was a lack of political support for the uranium association because nobody was emphatically demanding it. In contrast to the rocket experts around Walther Dornberger and Wernher von Braun, Erich Schumann missed the opportunity to secure the support of the highest circles for the uranium project.

Heisenberg's Reactor and Bomb Theory

On September 26, 1939, the HWA Uranium Association met for the second time in Berlin. Now Werner Heisenberg also took part. He was given the task of dealing with the theory behind the »uranium machine«.34 As early as December 6, 1939, he presented his thoughts on the construction of a reactor to the HWA Uranium oxide would behave in combination with different moderators. He saw the safest method of building a uranium machine in enriching the isotope U235. The more uranium is enriched, the smaller the machine can be built. "Furthermore, it [the enrichment of U235] is the only method of producing explosives that exceed the explosive power of the strongest explosives hitherto by several orders of magnitude."35 Heisenberg continued, however, normal uranium was also suitable for generating energy if one combined it with other substances that slowed down the neutrons without absorbing them.

This required a braking substance, the moderator, with the lowest possible atomic weight. Water seemed unsuitable to him as a moderator, so he suggested heavy water or pure carbon.

The basic requirement was to work with highly pure substances. Neutrons could be lost not only by being trapped in the U238, the moderator and all the other materials used in the construction of the reactor, but also by contamination of these materials. The "nuclear purity" therefore played an extraordinary role in the technical implementation of nuclear fission, as was to be shown in the first reactor experiments.

Finally, the neutrons could also be lost for further nuclear fissions because they flew completely out of the uranium. The uranium therefore had to have a certain minimum size. This minimum amount of uranium could be reduced by using a reflector. The reflector surrounding the experimental setup was intended to deflect neutrons that had escaped from the uranium machine.

All these questions, such as the minimum amount of uranium, the best moderator substance, the degree of purity of all substances used, the geometry of the uranium machine and its critical size, as well as the generation of heat in a reactor, had to be discussed further and examined in practice.

The problem of how a chain reaction could be stabilized by slow neutrons remained unsolved. At the beginning of December 1939, Heisenberg believed that he had found a solution for this as well. Excitedly, he explained to Bagge that the cross section – which is used to indicate event rates and reaction probabilities – decreases as soon as the temperature in the reactor rises. This meant that the reactor would stabilize itself at a certain temperature, in Heisenberg's example calculation this was eight hundred degrees Celsius.

On February 29, 1940, Heisenberg gave the HWA an updated version of his research report.36 This was already more reserved. The production of bomb material was no longer discussed.37 In addition, the researchers working with Heisenberg realized that they lacked the starting materials for building reactors. Significant amounts of heavy water were only found in Norway. Although uranium compounds were available, they first had to be processed into highly pure material. Graphite did not seem to be as suitable as an alternative moderator as originally thought. With this second report, Heisenberg anticipated the future development of reactor experiments. A stratified reactor made of uranium oxide and heavy water should now be built.

The research reports of December 1939 and February 1940 were the most important studies that Heisenberg wrote as sole author for the Uranium Association. He entrusted the further work to his assistants or it was done by other members of the Uranium Association.

Heisenberg's colleagues were very impressed by his research report. You now had a guideline for how to proceed. Harteck urged that no longer be satisfied with "ridiculously small experiments."38

Scientists in uniform head the KWI for Physics

With the takeover of the KWI for Physics into the direction of the HWA, there was also a change in the management. Schumann commissioned Walter Basche and Kurt Diebner to do this.39 Originally, he had even considered making Diebner the direct successor to the previous director, the Dutch physicist and Nobel Prize winner Peter Debye. He had refused to apply for German citizenship and accepted a teaching position in the USA. However, Albert Vogler, the influential new president of the KWG and director of the largest German group, Vereinigte Stahlwerke AG, did not want to accept a scientist who had not qualified as a new director. Basche and Diebner therefore acted as managing directors and not as directors.

While Basche stayed in the background and continued to reside in the offices of the HWA on Hardenbergstrasse, Diebner moved into offices in the Harnack building of the KWI in January 1940. The appearance of a "colleague in uniform" came as a shock to some of the key physicists at the KWI. They should never forgive thieves for that. As Carl Friedrich von Weizsacker put it, they had been given a "Nazi" under their noses. The real problem wasn't so much the uniform, which Diebner rarely wore, but his inadequate scientific reputation.
He didn't feel up to the new task alone. He therefore brought his friend, the theoretical physicist Heinz Pose, from the University of Halle to Berlin and made him deputy managing director.40 All the research reports of the Uranium Association ended up on

Diebner's and Pose's desks. Among other things, they had to decide when and to whom research reports classified as secret were to be forwarded and which reports could be released for publication. Counter-espionage and the destruction of secret files that were no longer needed were also part of their duties.

Carl Friedrich von Weizsäcker and Karl Wirtz opposed the new management particularly fiercely. One day Wirtz came to Weizsäcker and explained: "Listen, we have to get rid of thieves.

There's a way. We can see to it that we don't make Heisenberg the director of the institute.«41 They wanted to bring Heisenberg to the institute as an advisor. Weizsäcker presented this idea to Diebner. He didn't object. He knew his personal success depended on the progress of the uranium project. With Heisenberg, the chances of that were greater. From then on, Heisenberg came to Berlin once a week. The calculations of the "conspirators" paid off. Heisenberg's scientific authority was so great that he soon put his stamp on the work of the Uranium Association.

2. The Others

The Army Research Group in Gottow

A few months before Diebner became managing director of the KWI for Physics in January 1940, he had begun to set up a nuclear physics department at the HWA in Gottow. On the one hand, Schumann and even more so Diebner saw the opportunity to present themselves to their military superiors as promoters of atomic physics, on the other hand, for reasons of military secrecy, it seemed necessary for them to set up their own research center. Decisive experiments were not to be left to civilian institutes.42

Diebner's research center was to be located on the edge of the large Kummersdorf artillery firing range near the town of Gottow. Gradually, all the important departments of the HWA were brought together in Kummersdorf.43 In the context of this book, the Wa FI (Physics) department is important.44 It was responsible, among other things, for Sections I a (atomic physics) under Kurt Diebner and I b (explosive physics/ shaped charges) under Walther Trinks, each with ten employees.45 Diebner had to start from scratch in Gottow and

make do with a modest budget. He relied on young scientists devoted to National Socialism. All of his new employees were members of the NSDAP or one of its branches.

The first to come to the Army Research Institute was the physicist Friedrich Berkei. Berkei had belonged to the NSDAP since May 1937 and was a member of the SS.46 All other employees only joined immediately after the outbreak of war, including Werner Czulius, who had received his doctorate from Georg Stetter in December 1938.47 Third in the team was the astronomer Georg Hartwig.48 Also in October 1939, the physicist Walter Herrmann was committed to

Gottow.49 In addition to the permanently employed scientists and technicians, Diebner secured the support of external researchers at an early stage.5 " Until the end of 1942, Pose was the most important source of scientific ideas for the research group in Gottow October 1939

the Halle physicist Ernst Rexer was also drafted into the Wehrmacht. Diebner obtained his release from military service at the end of 1940.51 The work began with these scientists and several technical staff. The first major purchase was a neutron generator, after which the focus was on preparing a reactor experiment.

In view of the scope and complexity of the tasks, it was not possible for the Gottower group to work completely independently. In addition, the group lacked theoretical physicists who could be entrusted with the mathematical evaluation of the test results. None of the up-and-coming assistants of the great professors wanted to go to Gottow voluntarily.

But Diebner benefited from his position of power as managing director of the KWI for Physics. He was able to temporarily add scientists from the KWI to his group. Even more important were the expert opinions written by others on the Gottow experiments. Heisenberg and Weizsäcker were also involved in evaluating the Gottow experiments. For the most part, however, Weizsäcker's assistant Karl-Heinz Höcker was entrusted with this task.52 Diebner also received temporary personal support from the PTR. For example, Hans Georg Westmeyer helped prepare a reactor test. He was one of the best specialists in measuring methods in nuclear physics and in amplifier construction.

The HWA group was by no means self-sufficient. Of course, Diebner thought it necessary not to inform the competitors about all the details. It was not until 1943 that it became apparent that an efficient team had come together in Gottow, which had a better experimental approach than the groups of Heisenberg and Bothe.

The Navy's explosives physicists

The High Command of the German Navy (OKM) was also fascinated by the idea of building a »uranium machine«. One day it would power warships and submarines. This

Vision provided the impetus for their participation in the research into the »uranium machine«.

General Admiral Karl Witzell, head of the Naval Weapons Office (MWA) from 1934 to August 1942, was a firm supporter of the Navy's involvement in uranium research. As a participant in the meetings of the Uranium Association, he was well informed about the potential possibilities of atomic technology.53 Although he retired from active service on August 31, 1942, he remained influential in the Presidential Council of the Reich Research Council and took part in further meetings of the Uranium Association. He vigorously advocated a balanced relationship between purposeful research and basic research and an offensive conduct of the "research war. " Atomic research.55 A group of physicists, about ten scientists headed by the mathematician Helmut Hasse, was placed under the MWA's Office Group for Research, Inventions and Patents (FEP). Her superior was the former U-boat commander, Rear Admiral Wilhelm Rhein.56 At the end of 1941, Hasse

set up a research institute at Wannsee in Berlin. Basic research in nuclear physics was also carried out there. From the autumn of 1943 Hasse also had rooms at the University of Göttingen reserved for research work in the field of high-pressure physics.57 The experimental and explosives physicists of the Navy, who were ultimately important for the development of the nuclear weapon, worked at the Chemical-Physical Research Institute Dänisch-Nienhof (CPVA).58 Located about ten miles north of Kiel, this facility was one of the Navy's largest research facilities.

A second "uranium association" did not exist in the Navy, especially since the country's best-known physicists were already working for the HWA and the Reich Research Council. The marine group can best be compared to the thieves' group.

The MWA also lacked top-class theoretical physicists.
The market began to be sounded out, insofar as one could still speak of a labor market under wartime conditions. The Navy was able to at least three outstanding nuclear physicists

bind by contract – Pascual Jordan, Fritz Houtermans and Otto Haxel.

The most prominent of them was Pascual Jordan. He habilitated at the University of Göttingen in 1926 and, together with his teacher Max Born, made a significant contribution to the development of Heisenberg's matrix mechanics.59 Two years later, at the age of just 26, he was appointed to a chair in theoretical physics at the University of Rostock appointed. Jordan's main areas of work included quantum mechanics, quantum electrodynamics and cosmology. This is documented in numerous tributes to his person. But when the language comes to the years 1933 to 1945, his students become monosyllabic. This is because Jordan had become fatally close to the Nazi regime and was attempting to bridge the gap between the new physics, which ironically was largely shaped by Jewish scientists, and Nazi ideology. Jordan joined the NSDAP and SA in 1933 and volunteered for the Wehrmacht at the beginning of the war.60 He first came to the Luftwaffe's meteorological service in Potsdam before the Navy brought him to the Wannsee Institute in 1942 for secret research projects.

Unlike Jordan, Fritz Houtermans had nothing to do with the Nazis. He was one of the few communists among German physicists. After Houtermans had received his doctorate in 1927, he became an assistant to Gustav Hertz at the TH Berlin the next year and completed his habilitation with him in 1932.61 After Hitler came to power, the Houtermanses first emigrated to England and then went to Charkov in the Soviet Union in 1935, where they soon settled fell into Stalinist terror. Houtermans was arrested in December 1937 and suffered thirty months in various Soviet prisons. It was only thanks to the intercession of prominent personalities that he survived.62 At the end of April 1940 he belonged to a group of prisoners who were handed over to the Gestapo. In Berlin they were already waiting for the »homecomers«. The head of the Secret State Police, Heinrich Müller, dealt personally with the »returnees from Russia«.63

Again, Houtermans was lucky. His friend, the physicist Robert Rompe, found out about Houtermans' return to Berlin and

asked Professor Max von Laue to stand up for Houtermans. He actually managed to get Houtermans released at the end of July 1940. When Houtermans showed up at his former place of work at the TH Berlin, the surprise was great. There he met the young physicists Otto Haxel and Helmut Volz for the first time. Houtermans probably found out about the secret uranium project from Haxel. In the years that followed, they became friends.

For the time being, Max von Laue found a »wartime use« for Houtermans in the research laboratory of Manfred von Ardennes. His research reports written for Ardenne were probably the reason why the MWA began to take an interest in the extraordinary man. Despite or perhaps because of his background, he was sent to the Ukraine in the fall of 1941 together with Kurt Diebner and others. Their most important goal was the physics institute in Kharkov, where Houtermans had worked from 1935 to 1937.

Some old acquaintances then saw Houtermans as a »collaborator«. Did he want to win over Russian colleagues for the German armaments industry? This appears to have been planned, but in the spring of 1942 those responsible in Germany refused to allow Russian scientists to work on war-related research because of security concerns.64 Quite apart from the political circumstances, Houtermans had a very personal motive for his trip. He wanted to help the family of his friend Konstantin Shteppa, with whom he shared the prison cell. From May 1942, Houtermans became a scientific employee of the PTR as a "temporary conscript" and worked from then on on assignments for the Navy.65 The third

important scientist in the service of the Navy was private lecturer Otto Haxel.66 He received his doctorate in Tübingen in 1933 and had completed his habilitation in 1936 and had followed his teacher Hans Geiger as an assistant to the TH Berlin. Geiger granted Haxel a special position. From the very beginning he was allowed to work independently in the field of nuclear reactions and devoted himself, among other things, to the nuclear spectra of the light elements, a field that would later become very important.

In Tübingen, Haxel had joined the "Assistant Storm," an organization of the SA, and had been a member of the NSDAP since 1937

guided. After the beginning of the war he was released from military service to participate in the research of the uranium association. What he later reported about his work on the uranium project should be read with skepticism.

According to later testimony, Haxel put forward a proposal for an atomic bomb project in 1940, arguing that Germany must build such a weapon before the enemy did. However, he did not believe in the possibility of actually building such a weapon, but only hoped to receive research funds for the physics institute of the TH Berlin Uranverein wrote important studies on the materials that could be used for a nuclear

reactor.68 Already at this time he began to work for the MWA. At the beginning of 1943, Haxel was then officially drafted into the Navy and, according to his own statement, "brought physics into the Navy " . group of nuclear physicists and chemists.71 The naval group started its research later than the Uranium Association and the Gottower group. It was originally intended to concentrate on the construction of small nuclear reactors for ships and submarines and, like the Diebner group, cooperated on these issues with the KWI for Physics and the PTR. However, this work did not progress very well. The situation was different with the experiments on explosives physics.

The ambitions of the Reich Post Minister

After the war, Werner Heisenberg, Erich Bagge and other physicists were asked who, apart from the scientists from the Uranium Society, had been involved in nuclear physics research: "The Reichspost, it was (but) nothing serious."72 There was a certain arrogance in that. The Reichspost's attempts to set up its own nuclear project were not quite as amateurish.

The most ardent supporter of nuclear physics research was the Reichspostminister Wilhelm Ohnesorge, an old "fighter" who proudly wore the gold badge of honor of the NSDAP. During the war, it was not the formal position as Reich Minister, but rather personal relationships with Hitler that determined the influence and potential of the respective department.73 In this respect, Ohne sorge had a number of undeniable advantages.74 Even

before 1939, the Reichspost took on a number of projects important to the war , such as voice encryption and the development of radar devices. With the expansion of armaments research, Ohnesorge wanted to increase his political weight. For this purpose in particular, the research institute of the Deutsche Reichspost was founded on January 1, 1937, and its staff quickly grew to more than a thousand employees.75 In Kleinmachnow near Berlin, the studied physicist Ohnesorge tried to realize his vision of a scientific-technical think tank .

The young scientist and entrepreneur Manfred von Ardenne was one of the partners of the Reichspost. In 1926, after only four semesters, he gave up studying physics, chemistry and mathematics and set up his own research laboratory for electron physics in Berlin-Lichterfelde. Television research established the close cooperation between Ardenne and the Reichspost. In 1934 the Reichspost had a laboratory set up for him in the Reichspostzentralamt Berlin-Tempelhof. At the beginning of 1938, Ardenne succeeded in concluding a large research contract with the Reich Post Ministry. His institute was able to cover a large part of its expenses from this.

As early as December 1939, the successful autodidact drew the Reich Post Minister's attention to the "tremendous importance" of nuclear fission.76 A clever move from the point of view of science policy. The Reichspost had a large budget for basic research and an expert minister with a thirst for authority. He decided to support the project proposed by Ardenne “for the technical development of processes and systems in the field of atomic destruction”.77 In January 1940, the Reichspostforschungsanstalt and the private institute Ardenne concluded a contract, which was followed by others up to 1943. your

The subject was the construction of cyclotrons for the institute in Berlin-Lichterfelde and the development of processes and systems for isotope separation.

A 1-million-volt system for the production of radioactive isotopes and a 60-ton cyclotron were to be built with funds from the Reichspostforschungsanstalt. The cyclotron laboratory was referred to as the »Nuclear Physics Institute of the Reich Post Ministry«. Admittedly, after the war, Ardenne denied having ever thought of using nuclear research for military purposes.

Apart from the unfinished cyclotron, Ardenne's laboratory was one of the best equipped research facilities in the German Empire. Probably in response to Ardenne's insistence that the Reichspost should also turn to atomic research, an office for special physical questions (APS) was founded in Miersdorf (Mark Bandenburg) at the end of 1939.

The surviving files do not reveal why the Reich Post Minister decided to set up another nuclear research facility in Miersdorf parallel to the orders placed with Ardenne. However, it can be assumed that, like Schumann, Ohnesorge wanted to set up his own research complex under his sole control.

Outstanding among the Miersdorf scientists was Siegfried Flügge, who had switched from the KWI for Chemistry to the APS and had already published two important articles in August 1939 on the possible uses of nuclear energy.

The few research documents that have survived show that both the Ardenne institute and the Miersdorf institute focused on basic research in nuclear physics and isotope separation. The Reichspost did not tackle its own reactor project. The human and material requirements for this were lacking.

From the spring of 1942, the research work of the Reichspost was coordinated with that of the Uranium Association.78 Competitiveness still dominated and no one really let their cards be seen, but now there was a direct link between the Reichspost researchers and the authorized representative for nuclear physics in the Reich Research Council.

A few years after the end of the war, Henry Picker, who as a lawyer took part in Hitler's table talks in the Führer's headquarters and recorded them until the summer of 1942, claimed that, in addition to the Office for Special Physics Questions, there were other institutions in which the Reichspost had nuclear physics questions worked.79 Picker claims to have heard of an underground Reichspost production site in the southern Harz Mountains, where prototypes of small uranium bombs were said to have been developed. Since its publication, rumors in this regard have never entirely died down. Apart from the fact that there was no underground "nuclear laboratory" of the Reichspost in the Harz Mountains, questions remain unanswered: Why was the establishment of the Office for Special Physics Issues, which had started early, so slow? Did the Reichspost enrich uranium?

New markets for industry?

When new developments in atomic physics became apparent in the early 1930s, the Siemens Group decided to become active in this field as well.80 The company expanded Research Laboratory II into a center for research into gas discharge, electron and atomic physics, because Carl Friedrich von Siemens had learned that Nobel Prize winner Gustav Hertz had to give up his professorship at the TH Berlin and was considering taking on a new job at the Dutch company Philips. Siemens absolutely wanted to keep the scientist in Germany.81 In the years that followed, Hertz worked on the construction of particle accelerators.

The second largest German industrial group, IG Farbenindustrie AG, also came into contact with the uranium project at an early stage. It is possible that IG Farben's role was not limited to the supply of gaseous uranium compounds and heavy water. A secret HWA protocol reveals that Carl Krauch, the chief representative for the chemical industry, was planning a »parallel development in the field of atomic physics (uranium)«.82

In addition to the large companies in the electrical and chemical industries, companies from the aviation industry also expressed their interest in nuclear physics research. An example of this was Henschel Flugzeug-Werke AG. Professor Herbert Wagner, one of the country's best development engineers specializing in remote-controlled missiles , worked here.83 At the beginning of August 1941, Wagner and two colleagues wrote a report on the status of nuclear physics and its possible applications. The Henschel engineers drew visions of nuclear-powered submarines and airplanes. Wagner, who at best knew only vaguely about the research of the Uranium Association, was nevertheless able to assess that the separation of the rare uranium isotope 235 was the decisive step in the production of a new "terrible explosive". From this he drew the obvious conclusion: »The legitimate prospects for future technology are so numerous and varied that one must not fail to take an active part in this new development. « The Henschel engineers did not stop at their visions, but in the years that followed worked on concrete projects in cooperation with the Reich Ministry of Aviation.

With regard to industry, it can be said that among the major German companies, Siemens, IG Farben, Henschel and Degussa, the parent company of Auergesellschaft, expressed a keen interest in progress in nuclear physics. They had in mind the military use of the new technology as well as future market opportunities in the energy sector.

How many research groups were there?

The most important nuclear physics work was undoubtedly done by the Uranium Association. Only the Kaiser Wilhelm Institutes, together with the university institutes, were able to tackle the entire spectrum of uranium research. Originally, two tasks were to be treated equally - isotope separation and the construction of a reactor. This research served two purposes. They were interested in the construction of an energy

generating machine and the extraction of bomb material.

The army, navy and air force each had their own large research facilities, including departments for defense physics and explosives chemistry. It made sense to set up small research groups in their weapons offices to deal with questions of nuclear physics. These groups were initially unable to work completely independently of the Uranium Association because they lacked the personnel to do so. In contrast to the Uranium Association, where university professors set the tone, the goals of the Army and Navy research groups were clearly defined. The military promised their researchers the development of new explosives and small propulsion reactors.

The Luftwaffe also tried to get an insight into the status of nuclear physics work through cooperation with the Reichspost. More openly than any other science manager, Reichspostminister Ohnesorge stated what he hoped for from the work of his research institutes – the development of atomic bombs.

Did the SS also have its own nuclear research group? Certainly not in the early stages of the war. Later, the Black Order had ambitions to have a say in nuclear physics research. These endeavors did not result exclusively from current problems, but must be seen against the background of the SS's concept of power. The SS sought significant influence in all areas of society.
Intellectuals who, as SS members "on a special assignment," played important roles in industry, the military, and science, were brought in for this purpose. Only in the final phase of the war did the Technical Office of the SS become increasingly involved in matters of nuclear physics.

All in all, it is amazing how many places in Germany deal with nuclear physics issues. In order to be able to assess the level of work of all these groups, it is not enough to just look at the KWI for Physics. Werner Heisenberg was undoubtedly a key figure, but there were other talented minds.

3. Starting difficulties

uranium ore and heavy water

The Munich Agreement was signed on September 29, 1938, as a result of which the Sudeten region came under the German Reich. The Joachimsthaler mines, the oldest and most important European uranium mines, also fell under German control. Only German manufacturers were now supplied, first and foremost the Auergesellschaft, in which Degussa held the majority of shares.84 The physicist Nikolaus Riehl was head of the excellently equipped radiological department of the Auergesellschaft in Oranienburg. In the spring of 1939 he was among the first to draw the HWA's attention to the importance of uranium fission and to offer the services of his company.85 After the occupation of Belgium and

France by the Wehrmacht in the summer of 1940, the Union of Brussels also became Miniere, one of the world's largest uranium producers , included in the German uranium project. In general, foreign raw material deposits played an important role. The dependency was greatest when it came to importing heavy water from Norway.

It has only been known since 1931 that heavy water (D2O) exists. The American physicist Harold C. Urey accidentally discovered that the residual water in technical electrolysis cells contains many more heavy hydrogen isotopes (deuterium) than ordinary water.86 For the Industry seemed irrelevant to the discovery. Heavy water was all the more interesting for physics because important differences between isotopes could be detected for the first time with this substance.

Since 1934, heavy water has been produced by the Norwegian company Norsk Hydro as a by-product of the electrolytic production of hydrogen. The hydrogen, in turn, was a starting material for the Haber-Bosch process for producing ammonia. It took a thousand kilowatt hours of energy to produce one gram of heavy water. Such a

complex process was only worthwhile as a side process, but hydroelectric power was cheap in Norway. In this respect, the technical conditions at Norsk Hydro were an exception. No other country in the world had a comparable system before the Second World War.

In Germany, it was the physical chemist Carl-Friedrich Bonhoeffer, a student of Otto Hahn and later professor of physical chemistry at the University of Leipzig, who was the first to study heavy water in 1933.87 In addition to Bonhoeffer and his assistants Karl Wirtz and Herbert Hoyer in Leipzig, a second group at Paul Harteck in Hamburg dealt with the heavy water. Finally, the Munich physical chemist Klaus Clusius should also be mentioned, who worked in cooperation with the company Linde AG on a new process for the production of heavy water. In addition, scientists from IG Farben participated in the heavy water research.

At the start of the uranium project, the German physicists only had a few liters of heavy water at their disposal. On January 4, 1940, Diebner, Heisenberg, Wirtz, and Bonhoeffer discussed the problem. With foresight, Diebner proposed the construction of a large-scale heavy water plant in the Reich. Heisenberg rejected this with reference to the basic research that had not yet been completed.88 Here, for the first time, a recurring pattern of Heisenberg's behavior becomes apparent: while other scientists favored quick decisions and the transition to large-scale experiments, he advocated a systematic, slow approach.

In addition to Diebner, Harteck also pushed for concrete steps. He suggested that the HWA should have the catalytic exchange process researched.89 Harteck had already written to Heisenberg in a letter dated January 15, 1940 that the development of new processes for heavy water production was “on the shoulders of us poor experimenters” and that the Heavy water procurement would take “years”. Therefore, together with big industry, he wanted to reduce the development time to "a fraction."90 Diebner supported Harteck and contacted IG Farben

on. The company was supposed to buy 190 liters of D2O from the Norwegian company for the HWA, i.e. almost the entire stock.91 This request aroused the suspicions of the Norwegians. In February 1940, Norsk Hydro then announced that it had no intention of selling its reserves or increasing heavy water production.

When the director of Norsk Hydro was advised by French bankers of the military importance of heavy water in early March 1940, just a month before the German attack on Norway, he made the entire supply available to the French free of charge. The precious cargo made its way to France via adventurous routes and to Great Britain after the German attack.92 After Norway was occupied in April 1940, the Army

High Command (OKH) sent Dr. Oster, a representative of IG Farben, to Norsk Hydro. He was to find out how much heavy water the company still had and what production capacities were available. His report was disappointing: "Deliveries to the western powers took place under somewhat strange circumstances, it is assumed that they were used for the same purpose as ours."93

In the production of heavy water, the first enrichment stage was always the most difficult, since very large quantities of water or hydrogen had to be processed. For economic reasons, it seemed impossible in Germany to set up all stages of electrolytic heavy water production.94 Nevertheless, in the first few months of the uranium project, the HWA also had options for producing heavy water in the Reich area examined. The most economical method appeared to be the simple fractional distillation of ordinary water. However, this required comparatively huge distillation columns. The experts calculated that a column fifteen meters high would deliver only a few grams of heavy water every day. In hindsight, it would have been quite effective if the HWA had opted for this procedure.

Almost every major German chemical plant could have built and operated such a plant. Possibly competitors

Rationale considerations play a role as to why fractional distillation was only resorted to when it was already too late. Understandably, Clusius wanted to market the process he had developed together with Linde, and the Hamburg group felt the same way.

Heavy water technology was not a priority for the HWA at the beginning of the war. Why invest a lot of money in building new plants in Germany when there was already a functioning plant in Norway?

Problems in cyclotron construction

The situation was similar in the case of particle accelerators. In the construction of these facilities, which are extremely important for basic research in nuclear physics, Germany was clearly lagging behind. In the USA, more than thirty cyclotrons were already in operation or under construction, and in Germany, despite several ambitious projects, still none. The leaders of the various projects insisted on privileged treatment and jockeyed for scarce funding.

The threads for the cyclotron development came together in the Siemens laboratory with Gustav Hertz and his colleague Werner Schütze. The HWA was also interested in building a cyclotron.95 Since it was not possible to participate in the projects that had already started, the HWA opted for one of its own. It was given the code name »High Voltage Generator S«. Behind it was a large cyclotron with a 270-ton magnet.

Shortly after the beginning of the war, the Reichspost also commissioned the construction of two cyclotrons. For Ohnesorge it was probably a question of prestige to be the first in Germany to have cyclotrons. The poorly coordinated approach and the jealousies hampered all projects. Ultimately, only the cyclotron for Bothe in Heidelberg could be put into operation, but only at the end of 1943.

As in the case of heavy water and uranium, the German lightning victories also seemed to raise the cyclotron problem

to find a solution. The HWA was informed that there was a semi-finished cyclotron in Paris that had been built by the Swiss company Oerlikon.96 Schumann and Diebner had inspected the facility and also studied research documents confiscated from the French military and the secret service. The war had forced the French to abandon their reactor tests, otherwise they would probably have been the first to build a self-exciting reactor. The idea of using uranium in the form of spheres or grains in a reactor appeared in their patents.97 A good two years later, Diebner would fall back on this idea.

Schumann had to decide what to do with the Paris facility. Dismantling and relocating the cyclotron parts to Germany did not make sense. A compromise was agreed with Joliot Curie: the cyclotron was not relocated, but the French had to undertake to complete the facility together with German scientists and to allow the Germans to carry out non-military experiments.
However, the post-war accounts did not mention that Kurt Diebner took over the management of the institute.98 In

January 1942, the Paris cyclotron went into continuous operation with a power of seven megavolts (MeV). It was later upgraded to twelve MeV. It was by far the strongest neutron source available to the Uranium Society. First, the uranium and thorium preparations for Otto Hahn's research group were irradiated.99

In August 1941, two engineers from the Henschel works visited Joliot-Curie's institute. Professor Herbert Wagner had arranged this trip to gain more precise knowledge about the cyclotron. The engineers recorded the results of their talks with Erich Bagge, who temporarily managed the construction work in the Paris cyclotron: »The Americans, British and French are working very hard in the unoccupied area and using the greatest resources to generate energy from fission reactions, so that it it cannot be ruled out that one day they will surprise us with airplanes powered by uranium engines and uranium bombs. It was clearly pointed out by him that

that it is high time that a cyclotron was built in Germany and that nuclear physics was dealt with on a large scale.«100 Bagge explained to the engineers the problems of the

cooperation between German physicists and Joliot-Curie and assessed him as not reliable enough , in order to be able to carry out uranium fission experiments in his institute. These were to be carried out secretly in Germany. He described it as a "real disgrace" that there was still no cyclotron in Germany and assessed the German deficit in this area as fatal. He practically pressured the Henschel engineers to take care of the cyclotron construction together with the Reich Ministry of Aviation and the HWA. The establishment of a centrally managed »Reich Institute for Nuclear Physics« was seen as desirable. This is the only way to ensure that research does not “get lost in areas that are too abstract and far from usable”.

As suddenly as the Henschel employees appeared, they disappeared again. Later, little was heard of the company's activities in the field of nuclear physics. However, their journey was not without consequences. The Reich Air Ministry began to take an interest in "nuclear destruction plants."

While the Air Force went its own way from then on, the situation at the Paris Institute remained tense. The French and Germans used the cyclotron interchangeably and distrusted each other. There were also tensions between the German scientists. The exact work carried out by the German scientists in Paris between 1942 and 1944 has never been known. In the post-war period, everyone involved spoke only of basic research. However, it can be assumed that the most powerful neutron source in the German sphere of influence was primarily used for research in the interest of the HWA and the Reich Research Council.

The first reactor test

The breadth and intensity of the Uranium Society's research in the first months of the war was remarkable. This is evidenced by 65 reports up to the end of 1940 alone. The focus was on theoretical work that was useful for the construction of a uranium reactor. The decisive theoretical calculations for its construction were made by Carl Friedrich von Weizsäcker, Karl-Heinz Höcker and Paul O. Müller at the KWI for Physics in Berlin.™! in the spring of 1940 they recommended building a stratified reactor made of uranium oxide and heavy water. Ordinary water or a graphite mantle could be used as a reflector.102

Uranium oxide was scarce. At the end of 1939, the HWA turned to the Berlin Auergesellschaft and commissioned the production of one tonne of very pure uranium oxide. From now on, for reasons of secrecy, only "Preparation 38" was mentioned. The manager of the research laboratory of the Auer Society, Nikolaus Riehl, had a uranium processing plant built within a few weeks, with which uranium oxide could be extracted from pitchblende. Uranium oxide went to the HWA for the first time as early as January 1940.103 The material was largely reserved for Heisenberg and Bothe. But it turned out that uranium oxide wasn't the best starting material. It contained traces of boron, a neutron absorber. In addition, handling the "Preparation 38" was laborious and also dangerous because of its toxicity.

While the colleagues in Berlin, Heidelberg and Vienna were still calculating, Paul Harteck was no longer behind his desk. He immediately wanted to take the experimental path. From Heisenberg's assumption that a chain reaction is dampened by rising temperatures, he drew the reverse conclusion: low temperatures must favor a chain reaction. In April 1940, Harteck outlined his idea for an experimental reactor to the research director of the ammonia plant in Merseburg (Leuna), Paul Herold. Harteck wanted to embed uranium oxide in dry ice (solid carbonic acid) and place a neutron source in the middle. Herold offered to provide the dry ice free of charge. But Harteck lacked uranium oxide. He suspected that the 180 kilos that he struggled to gain

would not be sufficient for a successful attempt. It was like that in the end. The measurements showed no neutron multiplication.

If Harteck had insisted on repeating his experiment with larger quantities of uranium and dry ice, he would probably have had a breakthrough as early as the summer of 1940.
While carbon was not an ideal moderator, it was a very useful one.
After the war he counted himself lucky that it didn't come to that. He explained to his students that he would not be in front of them if his dry ice reactor had become critical.104 Harteck had not installed any control devices.

How do you get the bomb stuff?

Work to extract the uranium isotope 235 began immediately after the Uranium Association was founded. The separation of the isotopes and the enrichment of U235 was technically an extremely difficult undertaking. Until then, no process had been achieved anywhere in the world by which the isolation of isotopes had been achieved on a large scale, apart from the hydrogen isotope.105

At the end of 1939, Diebner commissioned the physicist Wilhelm Walcher to build ten mass spectroscopes.106 These devices, also called separators at the time, were based on the electromagnetic method, according to which electrically charged particles of different masses travel through a magnetic field in different curved paths. The separator was able to separate the smallest amounts of silver isotopes, and theoretically the device should also work with uranium.

A thermal diffusion process developed by Clusius and Dickel seemed promising and cheaper.107 Their separating device, later called the Clusius-Dickel separating tube, initially consisted of little more than a glass tube and an electric heating coil wrapped around one side of the tube.

Diebner instructed the Hamburg working group to focus on the problem of isotope separation.
Wilhelm Groth then undertook a first comparative study

of the procedures. In addition to the Clusius-Dickel separating tube, the gas diffusion process developed by Gustav Hertz in the 1920s could have been used.108 Hertz, who did not belong to the Uranium Association, was not asked.

Groth and with him Wirtz from the KWI for Physics favored the separating tube. Although they also considered the gas diffusion process to be useful, they rejected it because of the very small enrichment per separation stage.109 It was only later that the value

of the gas diffusion process was appreciated, but not in Germany, but in the USA and the Soviet Union. Regardless of its immense cost, both major powers used it for the large-scale production of U235.

As with the search for the best moderator substance and methods of making heavy water, extensive research has not been done. Particularly complex processes were not discussed further. One was still in the stage of reason

site research and shied away from the transition to large-scale implementation of processes that had not yet been adequately tested. In addition, the Uranium Association had only modest funds at its disposal and the HWA was reluctant to increase the budget before the scientists could show a success. All previous results of the Uranium Society seemed to Schumann to be as invisible as the radioactivity.

In February 1941, Harteck and his colleague Johannes Jensen reported to the HWA that they assessed the chances of isolating the uranium isotopes with the separation tube as positive.110 However, this success report was premature. The problems remained unresolved. In the summer of 1941, Harteck had to admit

that it had failed.111 Erich Bagge, who had helped prepare the first meeting of the uranium association, thought about a new approach and designed a separation device that he called an isotope lock.112 Diebner was interested in the comparatively inexpensive process ted. He dismissed Bagge from Leipzig and transferred him to the KWI for Physics in Berlin. At the end of 1941, work began on building the isotope lock in the workshop of the KWI for Physics.

The other side

Immediately before the start of the war, German scientists had a head start, because the German Reich was the only country to have a uranium research group that was subordinate to the military. In addition, the most important European uranium ore mines in St. Joachimsthal came into German hands. After the lightning victories of 1939/40, other important advantages came along. The Germans had confiscated the uranium stocks of the Union Miniere, were in the process of expanding heavy water production in Norway and using it exclusively for their own purposes, and now also had a soon-to-be-operational cyclotron in Paris. The theoretical preparatory work was advanced.

But there were also restraining factors. The capacities of Norsk Hydro for heavy water production first had to be expanded and the Paris cyclotron could only be used in weekly rotation with the French scientists. In addition, projects to build more cyclotrons had not yet progressed beyond the drawing board stage.

War was still far off in the USA, so the danger that the Germans could build an atomic bomb was not taken too seriously. It was above all the Jewish emigrants from the Axis countries who urgently warned of the looming threat. The decisive impetus came from the physicists Leo Szilard, Eugene Wigner, Edward Teller, Victor Weißkopf and Enrico Fermi. The latter pointed out the possibility of a uranium bomb to the American Navy Department on March 17, 1939. His warnings went unheeded. Fermi then turned to Albert Einstein. Together with Szilard and Wigner, they prepared a letter to President Roosevelt on August 2, 1939. The famous letter, signed by Einstein, warned that uranium bombs could destroy entire cities. There were indications that the Germans were already working on the development of this new terrible weapon. Roosevelt responded and appointed an advisory committee on the uranium problem. Nothing more happened for the time being.113

The disappointed emigrants did not give up. They wrote a second letter to Roosevelt on March 7, 1940, which was again

stone signed. In it they informed the President that uranium research had begun in Germany in great secrecy at the KWI for Physics in Berlin. Similar news had meanwhile reached London. The decisive impetus also came in Great Britain from two emigrants – Otto Frisch and Rudolf Peierls.114 They wrote two short memoranda on the construction of a superbomb. The only defense would be to develop such bombs yourself. The memoranda startled the British government authorities.

The possible consequences of the discovery of nuclear fission were also discussed in the Soviet Union.115 However, the prerequisites for turning to this new field were not particularly good. Since the 1920s, the country's entire scientific system had come under pressure. Some Soviet philosophers had called for "bourgeois physics" to be contrasted with "proletarian physics." Many Soviet nuclear physicists had come under suspicion of ideological unreliability. A climate of fear prevailed in the universities and research institutes. Nevertheless, a group of young physicists around Igor Kurchatov in Leningrad was not discouraged. His students Flerov and Petrzak discovered that spontaneous uranium fission occurs in nature. Curious about how his colleagues in the West would react to this discovery, Georgi Flerov published an article in the Physical Review. To his astonishment there was no response. With a keen sense of imminent danger, he correctly interpreted the silence of his colleagues: uranium research had been declared military secret.

Moscow reacted by forming a uranium commission. However, in November 1940 there was a serious setback. Kurchatov presented a work plan at a major scientific conference. He thought it possible to build a heavy water reactor in the foreseeable future. The grandees of Soviet physics, however, wanted nothing to do with this plan. In view of the war in Europe it is wrong to put resources into such a vague project. They believed that mastery of nuclear technology was a matter for the next century.

SECOND PART

reactor tests

1. "A straight road to the bomb"

The silver bullet: from the breeder reactor to the plutonium bomb

When the American physicists McMillan and Abelson discovered the element plutonium in the spring of 1940 and published about it, people in Great Britain were appalled that such explosive information had been published. But London received the answer from Washington that uranium research was of little military importance and that there was nothing to worry about. The British knew better, they had long since heard about the founding of the uranium association and were deeply concerned. It was only after June 15, 1940 that the decision was taken in the USA not to publish any more work on nuclear physics.1 But it was already too late. Carl Friedrich von Weizsäcker was the first to come across the spectacular news. Discovery was in the air anyway. Kurt Starke from the KWI for Chemistry had already published the results of his test series in May 1940 and detected element 93 (neptunium) .2 A month later, the Austrian physicists Josef Schintlmeister and Friedrich Hernegger also came across the new element.3 They were able to provide unequivocal proof however, do not lead with their possibilities. As a result, their results received little attention.

It was different in the case of Weizsäcker. On July 17, 1940, he wrote a five-page report on "a possibility of generating energy from U238."4 Enrico Fermi, Irene and Jean Frederic Joliot-Curie, Otto Hahn and others had already established the existence of an element with a half-life of only 23 minutes created when natural uranium is bombarded with neutrons.

If this uranium isotope decayed further, Weizsäcker concluded, based on the American studies, that a new element would be formed. He called it "Eka Re", which means one step above rhenium in the periodic table of elements. "Eka Re 239" (Neptunium) is just as fissile as U235. The fundamental difference to the technically highly complex extraction of pure U235

was that the new element could be created in a reactor.

However, Weizsäcker was wrong in his assumption that the accumulation and decay process would stop with neptunium. In fact, however, as McMillan and Abelson explained in a second article in the June issue of the "Physical Review", neptunium decays into another element with atomic number 94 (plutonium) after renewed neutron attachment. This element, and not neptunium, is the most easily fissile. Weizsäcker then corrected his thoughts. He sent copies of his revised report to Heisenberg, Wirtz and Diebner. Three possible uses of the Element 94 were discussed. In principle, Weizsäcker considered nuclear rocket propulsion to be possible, but only in the distant future. "According to the current state of research, the development of two other uses is urgent: as a heating machine and as an explosive." Then he came to the most interesting point for the HWA: »Only highly effective substances can be used as explosives. Their energy development must in turn exceed that of previous explosives by a factor of about a hundred thousand. Its production presupposes the construction of the heat engine (if the expected replica occurs in it) or an effective isotope separation plant.«5 Diebner's answer to the sensational research report has not survived. Actually, as the person with military responsibility, he should now have pushed with all his might to follow the "silver bullet" to nuclear weapons, which led from the breeder reactor to the plutonium bomb, as quickly as possible. But what did he have to show his superiors so far? Modest test arrangements in Berlin, Heidelberg and Leipzig, which showed no neutron multiplication.

At that time, Diebner still looked in awe at the work of the great scholars. She, and not he, determined the measure.

At the time when Weizsäcker published his groundbreaking study ver taken, the war seemed as good as won from the German point of view.

In the summer of 1940 only Great Britain remained as an opponent. Germany signed a non-aggression pact with the Soviet Union in 1939. From the point of view of the HWA, there was no need to speed up the work on the uranium project. There were also personal inclinations. Erich Schumann favored the development of new warfare agents, while he conceded little more than a wallflower existence to the »Nuclear Physics« department. Schumann used to call Diebner's research "nuclear crap".

Heavy water or graphite?

Weizsäcker and Höcker were responsible for the theoretical preparation of the first reactor tests in the "virus house". Wirtz took care of the practical implementation. In December 1940 the first attempt BI (B stood for Berlin) began. No neutron multiplication was observed. Nevertheless, the scientists remained optimistic. They were certain that with alternating layers of uranium and heavy water, they would someday succeed.6 The next thing to figure out was how much of each was needed. Weizsäcker came to the conclusion that about five tons were needed each time.7 However, his estimate was still uncertain by a factor of two.

The biggest bottleneck was heavy water production. In 1941 the Norsk Hydro had produced less than a ton of D_2O . Without an increase in production, the Uranium Association would have had to wait several years before the required amount of D_2O was available.

An alternative to heavy water was graphite. Bothe and Jensen investigated the usability of graphite in Heidelberg. When the first measurements were made, Bothe did not have access to high-purity material.8 However, he assumed that he would get better results with better material. While Heisenberg wanted ultimate theoretical clarity before embarking on a large-scale experiment, Bothe thought differently. A well-founded thesis was enough for him to start an experiment. He suggested immediately building "a machine out of preparation 38 and coal," that is, out of uranium and graphite.

Bothe's suggestion pointed in the right direction. Further experiments with uranium and graphite would have shown the feasibility of this route. But Heisenberg refused.

Bothe was considered one of the best experimental physicists in the country, and Heisenberg was the king of theoretical physics. Both were being considered for the post of director of the KWI for Physics in Berlin. But Heisenberg did not want to give up the reins. He wanted to reserve the right to decide when and with what materials to start building a reactor.

Bothe, as would be shown several times later, avoided open confrontation. He received a new batch of graphite from Siemens and continued his measurements between June 1940 and January 1941. To his disappointment, the measured values were still below those of the spring. He concluded that graphite, even when in a highly pure form, is not suitable as a moderator. Little did he know, however, that the material he was using was not as pure as assumed.

Bothe's measurements contradicted the results of Georg Joos and Wilhelm Hanle. As early as spring 1940, Joos had obtained carbon of the highest purity in the laboratory by heating sugar and potato flour and pointed out that only carbon that had undergone thorough treatment could serve as a moderator, since other types of carbon were too heavily contaminated with cadmium and boron. Obtaining pure carbon from potato flour or sugar must have repulsed physicists. The idea went unnoticed.

It was only a year after Joos had communicated his idea to the HWA that he was given the opportunity to speak about it. In March 1941 he was invited to a conference at the KWI for Physics. He and Bothe presented their differing findings.9 Joos was only allowed a few minutes to speak at the large two-day meeting, while Bothe was given three quarters of an hour. Nothing is known about the course of the discussion. What is certain, however, is that Bothe's opinion carried greater weight than the objections of his colleague in Göttingen. The graphite route was not discussed any further.

Historians later claimed that the Germans had to forego the construction of a graphite reactor because their industrial

trie would not have been able to produce graphite of the highest purity.10 In addition, this substance was primarily reserved for rocket production. Both theses, the quality and the quantity argument, are not valid. Erich Höhne, the former director of Siemens-Plania-Werke, one of the leading graphite manufacturers in the world, wrote after the war: »There is absolutely no doubt that it would have been possible for us at all times to use electrographite for scientific purposes from a to produce and supply a higher degree of purity than was otherwise required for technical purposes.«11 In his reply to Höhne, Heisenberg blamed the authorities for this lack of information. So it wasn't the industry's fault that construction of a graphite reactor wasn't started as early as 1940. They didn't even ask Siemens.

It was not technological constraints that led to the unalterable concept of the heavy water reactor, but rather the theoretical approach of the main players and their cost minimization strategy. Now the reactor depended, for better or worse, on the availability of extremely scarce heavy water. Despite this, Heisenberg did not push for an acceleration of the project or the construction of heavy water plants in Germany. He relied on a systematic approach that would one day lead to the construction of a uranium machine.

In addition to the Berlin group, Heisenberg had a second iron in the fire at his Leipzig institute. There he based his experiments primarily on the Döpel couple. In June 1940, the preparatory work for the first spherical layer test (LI) began, it did not produce any neutron multiplication. In the second experiment (LII) a small amount of heavy water could be used for the first time. Still no neutron multiplication could be measured. But when Döpel repeated his calculations, also taking into account the neutrons that were "swallowed" by the aluminum mounts, he arrived at a positive neutron multiplication coefficient. That meant the machine was already producing more neutrons than were being emitted by the radium-beryllium source. Now Heisenberg and Döpel knew that they were on the right track.

Houtermans' report of August 1941

Fritz Houtermans, who had successfully escaped the prisons of the Soviet secret police and the Gestapo, was employed by Ardenne in the summer of 1940 and entrusted with two important jobs. He was to participate in the theoretical preparatory work for the construction of a mass spectrograph and deal with a study on the theory of the chain reaction. He solved both tasks with flying colours. On 39 pages he laid down his thoughts »On the question of triggering nuclear chain reactions«. He recognized the importance of fast neutrons for an uncontrolled chain reaction and pointed the way to the production of plutonium. He recognized that the path he had mapped out, provided the necessary political and economic course was set, could lead to the construction of a breeder reactor and thus to the production of weapons-grade plutonium to speak plutonium bomb.

In the spring of 1941, Houtermans discussed his work with Heisenberg and Weizsäcker on several occasions. He said he felt pressured by Ardenne. He could not refuse his research assignments, but would only write in his publications what was already known in the Uranium Association.12

In March 1941 he sent a message to American physicists via his friend, the Jewish physicist Fritz Reiche, who was leaving for the USA. Orally he told him that the Americans should hurry up with their nuclear project. Work is already underway in Germany: "Heisenberg [is] unable to withstand the pressure from the government to start building the bomb in earnest any longer."13 However, Houtermans' message did not reach those responsible for the Manhattan Project.

If one believes Robert Jungk's descriptions, then Houtermans, Heisenberg and Weizsäcker agreed not to mention the importance of element 94 to the HWA. Houtermans is said to have even ensured that his groundbreaking work on plutonium extraction was classified as "top secret".

classified and locked away.14 This story of passive resistance has a flaw, however, because Ardenne did not withhold his colleague's study, but instead sent it to about forty leading physicists throughout Germany in August 1941.15 Neither did Weizsäcker's report of June In 1940 there was no official reaction

to Houtermans' August 1941 article or to an article by Victor M. Goldschmidt published in Norway in January 1942.16 The science journalist Thomas Powers has this to say about the obtuseness of the HWA attempted to explain it.17 However, Diebner and Pose were informed about the "royal road" and were willing to follow it, but they lacked the backing. Since they were not yet conducting their own reactor experiments at that time, they were dependent on the progress made in the "Virus House", in Leipzig and in Heidelberg.

The evaluation of the reactor experiments was in the hands of Heisenberg's and Bothe's employees. They, and not Diebner, determined the pace and direction of the work. Even knowing about the "silver bullet" did little to change the problems facing the uranium association.

Weizsäcker's unknown reactor and bomb patents

As early as the beginning of 1940, Heisenberg had asked Weizsäcker, Höcker and Müller to deal with the calculation of energy production in reactors. In May 1940, Müller also wrote a report on the “Conditions for the Use of Uranium as an Explosive”.18 He sketched an unstable reactor, later also referred to as a “reactor bomb”. This concept, which came about under the influence of Heisenberg, Wirtz and Weizsäcker, testified to the lack of understanding of the problems involved in building an atomic bomb. The "reactor bomb" was even to be included in a patent.

The scientists at the KWI for Physics summarized the status of their research in early 1941 in the publication »Technical Energy

nation, neutron production and production of new elements by fission of uranium or related heavy elements«. The specification was submitted to the Reich Patent Office in February 1941.19 Wirtz, Weizsäcker, Höcker and Müller apparently contributed to the drafting of the patent claims.20 The original of the patent specification is believed to have been lost. However, the correspondence between the KWI for Physics and the Reich Patent Office contains conclusive details. Accordingly, the Reich Patent Office was not satisfied with the brief explanations of the patent claims and raised objections on February 26, 1941.21 Wirtz countered this with the wording of the patent specification: “A thin plate made of the uranium isotope 235, covered on both sides by thicker paraffin plates or the same from the water of a steam boiler to be heated, forms a radiator with an enormous heat supply. This arrangement may have practical imperfections. However, based on the current state of knowledge in nuclear physics, one thing can be described as completely certain: A U235 plate a few millimeters thick and, for example, 1 square meter in area, surrounded by paraffin or water, would either have a permanent emit tremendous heating power or release their energy explosively with a force a million times superior to all previously known explosives.«22

There are several points worth noting about this reply. On the one hand, the KWI physicists still assumed that the rare U235 was absolutely necessary for the construction of a heat engine. On the other hand, Wirtz addressed two possible uses of the invention: the heat engine and the reactor bomb. He wrote: "Both cases should be protected by the patent application."23

After the objections of the Reich Patent Office, including several references to mature French patent specifications from 1939 and new research results from their German colleagues, the scientists at the KWI had to fundamentally revise their patent application. Paul O. Müller's reactor bomb concept was nonsensical. Weizsäcker recognized this. He had pointed out the plutonium route a few months earlier. It was better to take plutonium from a reactor and make a bomb out of it than blow the reactor up. Müller's idea was hardly

more than a short episode, which, however, is used in post-war literature as proof of the Uranium Association's lack of competence had to.

In the documents of the KWI for Physics in Moscow I came across a four-page report by Weizsäcker, probably from the early summer of 1941. Only two copies of this paper were made for the HWA, the original remained with the KWI for Physics. Weizsäcker appended six patent claims to the report.24 Five of the six patent claims dealt with the possibility of generating energy from plutonium. Weizsäcker found the construction of small reactors particularly interesting. He knew, of course, that plutonium was a bomb material: "This explosive would exceed any other explosive per unit weight by about ten million times in terms of energy released per unit weight and could only be compared with pure U235."25 He made the following claim: " Method for the explosive generation of energy and neutrons from the fission of the element 94, characterized in that the [...] element 94 is brought to a place, for example in a bomb, in such a quantity that the fission results The vast majority of neutrons are used to stimulate new fissions and do not leave the substance.«26 A German patent claim for a plutonium bomb from the summer of 1941 !27

We do not know whether Carl Friedrich von Weizsäcker only saw the plutonium bomb as a possibility in the distant future and wanted to secure the rights to use it. That he included this point in his writing at all is remarkable. He had thus described the technically simplest way to produce an atomic bomb.

At the time of writing his patent claims, Weizsäcker still harbored the naïve hope that he could gain political influence through his successful scientific work.28 If he succeeded in constructing an atomic bomb, even Hitler would talk to him, and he could moderate his opinion affect him. His father, Ernst von Weizsäcker, State Secretary in the Ministry of Foreign Affairs, had similar views.

In the summer of 1941, the patent question had to be clarified in an intimate circle

have been. Weizsäcker's solo effort was probably met with criticism. The idea of being able to impress and influence Hitler with a new invention may not have convinced his friends. In addition, he had not developed the reactor theory alone. In any case, Weizsäcker subsequently no longer acted as the sole applicant for reactor patents. More importantly, the word "bomb" disappeared from official correspondence.

On August 28, 1941, another patent was submitted by the KWI for Physics.29 There is no longer any reference to a bomb. From now on there was only talk of the "uranium machine", i.e. a reactor for generating energy.

The patent applications dragged on until the end of May 1943, accompanied by violent arguments with the Second Physics Institute of the University of Vienna.30 Later, all reactor patents were filed in a secret department of the Reich Patent Office set up specifically for this purpose.

The small-group discussions about the consequences of discovering the "royal road" took place at a time when Hitler was at the zenith of his power. The conventional strength of the German Wehrmacht suited Heisenberg and his associates. "Wonder weapons" were not yet expected of them. Nevertheless, they felt that they were at a crossroads. The discussions about the reactor patents had shown the dangerous direction in which the entire project could go. When there were indications of an increase in neutrons in the reactor experiments in Leipzig, a controlled chain reaction was on the way. The uranium association had abandoned harmless basic research.

The logic of the chosen path was the construction of larger reactors. They could have produced fissile material and used it in bombs. In principle, the nuclear weapon was feasible, even if the effort involved could not yet be overlooked.

Looking back, Heisenberg said: »From September 1941 we actually saw an open road to the atomic bomb in front of us.«31

He was worried: »We all felt that we had ventured into highly dangerous territory.«32

The leading nuclear physicists in Great Britain and the USA reacted quite differently to the discovery of plutonium. They pulled out all the stops to warn the relevant government agencies of a German bomb and to get support for their own research. Until then, work on the uranium project in Great Britain had progressed faster than in the USA. The British scientists came to the conclusion that atomic bombs were feasible. Churchill's support was crucial to the British advance. On September 3, 1941, the British War Cabinet made the decision to go ahead with the uranium project without reservation.

When the Americans were informed about British research in the summer of 1941, they also accelerated their efforts. In December 1941, shortly before the USA entered the war, President Roosevelt appointed a group of politicians to take care of the American nuclear project. In Great Britain and the USA, uranium research became the concern of the prime minister and the president, whereas in Germany only a few scientists knew about it.

While the rocket engineers around Wernher von Braun and Walter Dornberger never missed an opportunity to emphasize the importance of their research for the war, the scientists of the Uranium Association did nothing of the sort. Can this be interpreted as a kind of conspiracy against the construction of the bomb? Weizsäcker himself contradicted this interpretation fifty years after the event. Heisenberg, too, only reported discussions about the problem, not agreements.33 In an unpublished text written at the end of 1947, Heisenberg described his behavior as a form of active resistance. By coming to the top of the KWI for Physics, he had the chance to have a moderating effect. From then on he saw himself in the role of an active member of the opposition.34 A case of subsequent creation of legends?

Whatever you call it, the process of clarification among the Uranium Society's leading scientists caused them to slow down their pace of work. A look at their publications also shows this. After the summer of 1941, Heisenberg and Weizsäcker made no further significant research contributions to the uranium project.

A mysterious meeting in Copenhagen

From the beginning of 1941 Werner Heisenberg traveled all over Europe as an “ambassador of good will” for National Socialist Germany, visiting universities and German cultural institutes and giving lectures.35 Heisenberg represented the “good German”. Wherever he could, he helped foreign colleagues who got into trouble, and he didn't shy away from personal risks. His travels cannot be classified in a black and white grid.

In March 1941, Weizsäcker gave a widely acclaimed lecture in Copenhagen.36 On this occasion he also met Niels Bohr, although without talking about the reactor and the bomb. In September 1941, Weizsäcker went to Copenhagen again with Heisenberg. This trip and the conversations between Heisenberg and Bohr are among the most discussed events in the history of science of the 20th century.37 While Thomas Powers pays great respect to Heisenberg's attitude, because he not only informs Bohr about the existence of the German uranium project and thus a highly personal one Having taken the risk but even tried to persuade Bohr to agree not to continue working on the development of nuclear weapons, Paul L. Rose sees Heisenberg's trip as an expression of German cultural imperialism.38

The conversations between Bohr and Heisenberg were not recorded. All historians of science draw their knowledge of the connections from later, rather cryptic statements by Heisenberg, Niels Bohr's family and the memories of employees and friends who, however, were not involved in the discussions. Bohr himself never commented on Heisenberg's visit, but eleven letters to Heisenberg from the post-war period, which were not published until 2002, have survived.

Let's try to reconstruct what happened: Heisenberg went to Copenhagen at a time when Hitler's armies were victorious on all fronts. In Heisenberg's opinion, the Reich was locked in two separate wars, one against the Western democracies, which needed to be ended quickly, and one against the Bolshevik system, whose demise he sanctioned.

After the victory over the Soviet Union that Heisenberg expected, would there be an armed conflict against the USA? This idea worried him greatly. He knew the tremendous industrial and scientific potential of America.

Heisenberg was concerned with specific questions. What should he and his companions do? Against the background of Weizsäcker's plutonium bomb patent, Heisenberg's attempt to speak out with Bohr becomes even more dramatic. In the summer of 1941, he had learned from Swedish newspapers that a uranium bomb was being developed in the USA. How far were the Americans? Would they one day use this weapon against Germany? Such questions must have moved him in Copenhagen. Heisenberg saw a glimmer of hope in the fact that the production of atomic bombs would be extremely expensive. Summarizing his thoughts at the time, he said years later: “In the summer [1941], twelve people could have prevented the construction of atomic bombs by making joint agreements.”39 According to his account, he wanted the best physicists in the world to come to a quiet agreement with Bohr talk about preventing a nuclear race. After the war, Heisenberg described his idea as naïve and unworldly. Bohr was in Copenhagen, in a country occupied by German troops. He was not informed about the scientific advances on the Allied side. What could he have done anyway?

From September 18 to 24, Heisenberg and Weizsäcker visited the German Scientific Institute in Copenhagen and gave lectures there.40 All Danish scientists boycotted the event at this institute, but Weizsacker was invited to repeat his lecture at Bohr's institute. Heisenberg appeared there several times for lunch. During the table talks, Heisenberg evidently committed tactlessness that Bohr's colleagues did not forgive. He described the war as a "biological necessity" and was convinced of the imminent German victory.

Bohr was upset about this. Nevertheless, he invited Heisenberg to his house three times. Their legendary conversation probably took place on their second visit. The following exchange can be reconstructed from later statements: At the beginn

one about the war. Heisenberg defended the German invasion of Poland and said that he expected the Soviet Union to be defeated soon. Bohr did not accept this, he wanted nothing more than a quick end to Nazi rule.

Heisenberg's understanding of Hitler's war must have been a great disappointment to Bohr. Actually, the conversation had already failed.

Then Heisenberg changed the subject and suggested that Bohr show a minimum of cooperation with the German occupation authorities. Bohr was unsure of his interlocutor's intentions. Was he playing with open cards, or did he only want to use him for the purposes of the occupiers? Finally, Heisenberg came to the most important point for him. He asked Bohr if he thought it acceptable for scientists to research uranium in time of war. Bohr, who until then had thought it impossible to construct atomic bombs, responded with a counter-question: Can uranium fission really be used to construct weapons? Heisenberg's answer must have frightened him. "I know that this is possible in principle, but it would probably require an enormous amount of technical effort, which one can hope will not be made in this war."41 Bohr apparently even took the second part of the sentence

not true anymore.

In his letters to Heisenberg, written but not sent after the war, Bohr repeatedly stated that Heisenberg had given him to understand that the German uranium project was well advanced: »You expressed yourself in vague words in such a way that I got the unconditional impression that everything was being done in Germany under your direction to develop nuclear weapons and that you said there was no need to go into the details as you were completely familiar with them and more or less exclusively for the last two years worked on such preparations." In the next draft of the letter, Bohr went a step further. He thought he remembered that Heisenberg had informed him rather abruptly that "if the war lasted long enough it would be decided by nuclear weapons, and I didn't feel the slightest

ten indication that your efforts and those of your friends went in a different direction«.42

At the end of the conversation, Heisenberg Bohr claims to have asked whether all relevant physicists could agree not to develop atomic bombs. Now Bohr's measure was full. He reacted angrily: "Bohr may have already heard that I would prefer it if physicists all over the world said: We don't make atomic bombs. At the same time, however, he found that this is a terrible and almost pro-Hitler formulation or wish of Heisenberg [...] So many good physicists have gone to America, and the Americans are understandably so superior in this area. It is, so to speak, unfair that the Americans' self-inflicted superiority over Hitler [...] should not now be used. I thought I sensed this reaction in Bohr, and I also had the feeling that Bohr was quite right, that's actually also unfair.

Hitler drove the good people to America, and then he can't be surprised that the atomic bombs are doing. At the same time, I also had the feeling [...] that when you make atomic bombs, you cause a terrible change in the world. [...] I was just afraid of everything, including this possibility.«43 The conversation ended abruptly. But that was not the end of Heisenberg's visit

to Copenhagen. Bohr invited him a third time. He read something and Heisenberg played the piano. They didn't continue the fateful conversation of the previous day. The friendship between the two great scholars had developed deep cracks.

Heavy water, centrifuges and cyclotrons

At the end of September 1940, Wirtz, Harteck and the engineer Erhard Schoepke from the military economics staff in Oslo traveled to Norsk Hydro in Rjukan.44 There Harteck suggested increasing heavy water production by installing an additional plant. The Norwegians agreed and wanted to bear the cost of the expansion themselves. In return, they expected a long-term contract to deliver heavy water.45 This served both sides. In February 1941 Norsk Hydro confirmed that after the conversion it would be able to deliver one tonne of D2O by the end of the year and one and a half tonne each year for the next few years.46

While the theoretical problems of reactor construction appeared to have been largely solved and progress was also being made with regard to the production of heavy water, isotope separation had so far only failed. A coincidence came to the aid of the Hamburg group. In the spring of 1941, Harteck and Groth heard a lecture by the Kiel physicist Hans Martin on the gas centrifuge method. Perhaps she could do what the dividing tube couldn't? Diebner placed an order to build a centrifuge.47 Initial tests were successful. However, there was still a long way to go before it was ready for series production. In several letters, Harteck asked for further support for his experiments. But the HWA was about to withdraw from the uranium project.

This situation also had a paralyzing effect on the construction of particle accelerators. In June 1941, Siemens was working on three cyclotron projects. The company built a complete cyclotron for Hoffmann, a cyclotron magnet for Bothe and a large cyclotron magnet for the HWA.48 Krupp was supposed to cast the raw magnets, but expected delivery times of up to four years, because they also had the production of took over two further cyclotron magnets for the Reichspost.49

The tug-of-war over the order of the cyclotron projects was decided on November 27, 1941.50 Right at the beginning of the conversation at Siemens, Diebner made a crucial mistake. He explained that HWA had no direct right or desire to dictate the order of projects on its own. The Siemens experts explained that the two small magnets should be built first. In order to avoid a mutual blockade of the projects, Siemens wanted to remain the "sole spokesman and rely on the HWA or the Reich Research Council where necessary."51 The HWA was left with only the role of a junior partner. But Siemens was only half-hearted in constructing the cyclotron. Gustav Hertz noted in an internal memorandum: "Our research laboratory is not interested in the program."52 The behavior of Siemens and Krupp showed very clearly the low status of the uranium project in the German armaments economy at the beginning of the war.

The Army Weapons Office is backing down

In the fall of 1941, the war in the East seemed to have been won, and the Victory Parade on Red Square was already being planned. But in winter, the Wehrmacht suffered its first serious defeat before Moscow. On December 7, 1941, the Japanese Empire attacked the American Pacific Fleet at Pearl Harbor. Four days later, Germany declared war on the United States. The setback on the eastern front and the entry of the USA into the war fundamentally changed the strategic situation. Until then, Germany's military and industrial elites had hoped for a short war, but now the Reich was taking revenge on its failure to prepare its economy for a long war. The Reich Minister for Armament and Munitions, Fritz Todt, had seen the catastrophe approaching for weeks and pushed for a reorganization of the war economy. Hitler finally agreed.

This turning point had lasting consequences for industry and armaments research. From now on, only projects that will be of military use in the foreseeable future should be funded was expected.

In order to discuss the new situation and determine measures, Erich Schumann ordered the leading members of the Uranium Association to a conference in Berlin on December 16, 1941. Two and a half years had passed and there were still no usable results. Completely under the impression of the military-strategic turning point in December, Schumann suggested to the head of the HWA, General Leeb, that the army should gradually withdraw from the project.53 Leeb gave this idea to the new president of the KWG, Albert Vogler, at the beginning of February 1942. continue. He said that nuclear energy research had come to a “certain conclusion” and now had to be reorganized. The production of an "atomic explosive" could only be considered after the construction of a uranium machine.54 The future of the uranium project had to

be discussed again. This happened at two conferences on February 26, 1942 and June 4, 1942. The constellations were confusing. On the one hand there were the renowned physicists around Heisenberg, who wanted to concentrate on basic research and at best saw the construction of a nuclear reactor as a realistic goal. On the other side stood Diebner and his Halle friends. In addition to these two groups, there were numerous scientists working outside of the uranium project, each pursuing their own interests. The most important new player was Albert Speer. In February 1942, after Fritz Todt's fatal accident, he took over the office of Reich Minister for Armaments and Munitions. He was a brilliant organizer and managed to fundamentally transform the German wartime economy. He benefited from his friendly relationship with Hitler.55

On February 26, 1942, the Reich Research Council invited scientists and representatives of the Wehrmacht and SS to a nuclear physics conference. Erich Schumann opened with a lecture on »Nuclear Physics as a Weapon«. After that, Otto Hahn spoke about “the fission of the uranium nucleus”. The most important presentation was given by Werner Heisenberg, who briefly outlined the theoretical basis for generating energy from uranium fission, stressed the difficulties involved in extracting U235 and described the design principles of a reactor. Due to the transformatio

Reactor, it is possible to obtain the "element 94", i.e. plutonium. "Even the machine in operation can lead to the production of an incredibly powerful explosive."56 Why did

Heisenberg even mention the "royal road" in front of a large audience? Well, he couldn't suppress the new knowledge. They were known to the HWA, at least Thieves and Pose. Hiding the discovery of elements 93 and 94 could have raised suspicions. Therefore, Heisenberg may have decided on his risky strategy.

Few listeners would have grasped the full significance of his performance. Not even all the physicists present were aware of the difference between U235 and the Element 94. How should the military assess the state of research? Although Heisenberg had indicated that the production of an incredibly powerful explosive was possible, he immediately referred to unsolved technical problems. He avoided any reference to "critical mass," the amount of fissile material needed for an uncontrolled chain reaction.

During the breaks in the conference, the debates continued in small groups. There was talk of whether the work of the Uranium Association could be advanced enough to have an impact on this war. Planck, Geiger, Winkhaus and others said no. Geiger considered it “completely impossible that this project can be realized in Germany in the next few years”.57 Clusius was less pessimistic, but drew attention to the material costs: “The bosses of armaments will not agree to making cutbacks in the current armaments programs in favor of a huge project, the successful processing of which cannot be predicted very soon.«

During a pause, one of the generals, probably Field Marshal Erhard Milch, approached Heisenberg and asked him directly if he could produce a "war-decisive bomb" within nine months. Heisenberg said no. The general then turned to Bothe and asked him: "Would you agree with what Professor Heisenberg said?"58 Bothe said yes. For the military, the case seemed clear. Still impressed

the conference attracted the high-ranking audience and contributed to the fact that not only the army, but also the navy and air force leadership were now interested in nuclear physics.59 After the February conference, the research work was also coordinated with the Reichspost.

Propaganda Minister Joseph Goebbels was also impressed by the results of the conference. He noted in his diary: "Research in the field of atomic destruction has progressed so far that its results can possibly still be used for the conduct of this war. With the smallest effort, such immense destructive effects result that one can look forward with some horror to the course of the war, if it lasts longer, and to a later war.«60

In preparation for the conference in February, Diebner and his team were given the task of summarizing the state of research. He submitted a 144-page report.61 In the appendix, all 22 institutes involved in the Uranium Society's research were listed and an overview of the 137 secret reports produced to date was given. The document stood in stark contrast to Schumann's skeptical view. The introduction reads, “It will be possible to build a uranium energy source. As things stand at present, the pace of work aimed at the so-called uranium machine is essentially determined by material procurement issues."62 Then the controlled chain reaction in a reactor and the spontaneous one are explained, the latter represents "an explosive of the highest effectiveness." , but cannot yet be fulfilled with certainty.«63 Diebner therefore considered it possible to build a heavy-water reactor in the foreseeable future, and he also saw the construction of an atomic bomb as feasible in principle. British and American physicists had come to the same conclusion only a few weeks earlier.

With five tons each of uranium metal and heavy water, the scientists assumed, it would be possible to start a self-sustaining chain reaction in an experimental reactor. Diebner formulated the following steps unequivocally:

"1. The development of the machine into a technically usable apparatus. 2. The technical, especially military use of the machine. 3. The production of a uranium explosive [...] Task 3 requires very large isotope separation plants or a successful separation of element 94 in large quantities from the machine. The prospects cannot yet be estimated with certainty.«64 This relativization was disastrous with regard to the further funding or non-funding of the project by the HWA. Just over a month earlier, Erich Schumann had declared in a circular that only research that would bring concrete benefits in the foreseeable future was eligible for funding. A project whose prospects "could not yet be assessed with certainty" ran the risk of being put on the cross-off list. The accents were therefore wrongly placed in the conclusions. Ultimately, the decisive factor was that the optimists surrounding Kurt Diebner lacked a lobby. So his research report was ineffective.

The conference on June 4, 1942, at which the physicists of the Uranium Association met the military leaders of the Reich, was of great importance. Among others, Speer, his deputy Karl Otto Saur, Fromm, Milch (air force), General Admiral Karl Witzell (navy) and Leeb, head of the HWA, took part.65 The hosts were Albert Vogler and his general secretary Ernst Telschow. The atmosphere in the run-up to the conference was tense. From the spring of 1942, the Royal Air Force flew heavy attacks against German cities. Hitler raged and plotted revenge. The Luftwaffe leadership came under pressure. Milch examined plans for a bombing raid on New York. The results were sobering. The Luftwaffe did not have aircraft with such range. Later, in the fall of 1944, the idea of an attack on New York would be revisited.

The military now expected the scientists to build an effective weapon, as Lieutenant General Erich Schneider emphasized after the war.66 Heisenberg correctly assessed the mood of the generals. He couldn't avoid the pressure of expectation. To this day, Heisenberg's lecture is believed to have been lost and provided material for speculation.67 My surprise was all the greater when I found the text in a Moscow archive.68

Heisenberg first repeated the arguments he had put forward in February. Then followed a passage that caused movement among the audience: "I would like to mention at this point that, based on the positive results so far, it does not seem impossible that after the production of the uranium burner on one of v. Weizsäcker may one day produce explosives that are millions of times more effective than all previous ones." This statement immediately qualified Heisenberg and drew interest in the construction of a uranium machine: "But even if

this does not happen in the foreseeable future, If the production of the uranium burner succeeds, an almost incalculable field of technical applications will open up. I'm thinking on the one hand of the construction of watercraft, possibly even airplanes with a large radius of action, but then also of the infinitely diverse applications of the radioactive substances that can be obtained in the burner for many technical and scientific

problems. Such a burner could, with greater energy consumption, emit about ten thousand times as much radiation as the most powerful cyclotrons and, correspondingly, produce almost any amount of artificial radioactive substances.

The time until the technical development of such a burner is currently largely determined by material procurement issues, especially by the production of heavy water.

But apart from the material issues, a lot of scientific development work still needs to be done. Even if one takes into account the difficulties of such development work, one must be prepared for the fact that new territory of the utmost importance for technology can be opened up here in the next few years.«69 Then followed a passage in which Heisenberg

described the uranium project as promising: »Since we know that a large number of the best laboratories are working on this problem in America, one can hardly do without pursuing these questions in Germany. Even if one considers that such developments usually take a long time, one must reckon with the possibility that the technical exploitation of nuclear

nuclear energy can one day suddenly play a decisive role in the war." With the distant prospect of a bomb, Heisenberg wanted to convince the military to continue financing the project and exempt scientists from military service. He gave the construction of a reactor for power generation as a short-term goal. This was the daring strategy he had already pursued at the February conference. But in the meantime Diebner's research report lay

Before.

Most of those present remembered an exchange of words between Milch and Heisenberg. The Field Marshal wanted to know how big a bomb had to be to destroy a large city. Heisenberg gestured: "About the size of a pineapple."70 When he saw the faces of the military, Heisenberg immediately tried to to curb the rising euphoria. At the moment it is not possible to foresee how long this will take. In the near future you should concentrate on building a reactor.

With the reference that the problem of reactor construction had to be solved first, he was able to declare the project as a long-term project. You didn't have to talk about a gun until the reactor was up and running. The bill paid off. The project remained at the level of basic research, with simultaneous expansion of state funding.

To this day, the "pineapple comparison" has given rise to controversy. For Heisenberg's followers, it is proof that he had already roughly calculated the critical mass for an atomic bomb in 1941/42. This is also what Karl Wirtz suggested in his memoirs.71 The HWA report of February 1942 supports this view -100 kg) spatially«.72 It is clear from the context that the authors were referring to plutonium at this point. Incidentally, the estimate was hardly any worse than that of the scientists in Great Britain and the USA.

The physicist Otto Haxel, who worked for the Navy, also indicated after the war that it would not have been difficult for him and his colleagues to calculate the critical mass: "From the over-

From the calculations of Bothe and Heisenberg, it is easy to deduce how large a uranium sphere made of pure U235 or of an enriched mixture must be for the chain reaction with fast neutrons to take place.« He immediately qualified this remarkable statement: »However, such an estimate should should be disregarded, since the necessary experimental values [...] are known too imprecisely.«73 Heisenberg's

critics, on the other hand, refer to his statements from the summer of 1945. There he spoke of several tons immediately after he found out about the atomic bombing of Hiroshima pure U235, which are necessary for a uranium bomb. Otto Hahn then asked him in amazement: »Why did you always tell me that you need fifty kilograms to do something? Now you say you need two tons.”74 Heisenberg did not want to commit himself immediately, but admitted that he had not yet calculated the exact magnitude. However, he then set his ambition to find the solution and managed it within a week. The physics of the atomic bomb, he observed, 'is basically very simple; it is an industrial problem«.75

Here we encounter another fundamental point of contention. Did Heisenberg only succeed in calculating the critical mass after the war? If this is true, then it was his errors, not his conscience, that saved him from having to make a moral choice. However, Hahn's repeated reference to a few kilograms of U235 stands in the way of this.76

But let us return to the events of June 1942. Speer asked if a chain reaction could get out of hand and destroy the entire earth. Such fears were widespread in the political leadership of the Third Reich. Todt had already discussed with Hitler in 1940 that an atomic chain reaction could mean the end of the world. Heisenberg did not have a clear answer. His evasion, which the military and Speer could hardly understand, had a sobering effect. This impression was reinforced after the conference. When Speer asked Heisenberg and Weizsäcker how much money they needed to continue their experiments, they gave him a ridiculously small sum of forty thousand Reichsmarks. The Leipzig reactor tests had a

77 At the June meeting, there can be little doubt that Heisenberg could have called for all the support of the military and industry. But he didn't take this chance.

A damper for the Reich Post Minister

The leading scientists of the Uranium Society viewed the closeness of the Reich Post Minister, Ohnesorge, with suspicion. They thought he was meddling in things he didn't understand. The brisk entry of the Reichspost into nuclear physics research had increased the confusion in the construction of cyclotrons and high-voltage systems. Without worries, it knew how to get the Todt organization involved in the construction project and secured the support of the Reich Air Ministry. On October 8, 1941, Göring formally gave the Reichspost a research contract for “work in the field of nuclear physics” with the highest priority level.78 In return, the research management that had meanwhile been set up at the Reich Air Ministry wanted to be informed about the results.79 The focus of the Reichspost group’s work formed the isotope separation.

On November 28, 1941, Heisenberg visited the Ardenne laboratory. Fourteen days later, Hahn also paid a visit to the institute. Ardenne asked both colleagues how much U235 it takes to build an atomic bomb. They replied: "A few kilograms".80

The answers were grist to the mills of Ardennes. He had been working on the construction of an electromagnetic mass separator for several months. He was convinced that a few kilograms of U235 could definitely be gained with the support of the large German electronics companies. Possibly on the advice of Heisenberg, Weizsäcker also visited Ardenne a few weeks later. He informed him that Heisenberg had come to the conclusion that an atomic bomb would not work after all. As the temperature increases in a chain reaction, the cross section of U235 that would cause neutron multiplication decreases

consequently decrease and the reaction die off. What Weizsäcker explained here was nothing other than the analysis of the problem given by Niels Bohr in the late 1930s. He and many other members of the Uranium Association have long known that Bohr was wrong.

But did Ardenne know this too? In his memoirs, he took the view that Weizsäcker and Heisenberg had actually made a crucial mistake here and that German nuclear research had therefore failed.81 After this conversation, he lost his interest in nuclear research. This is one of many legends surrounding German nuclear research. Ardenne's ambitions may have been dampened in the spring of 1942. He has by no means given up his efforts. Ohnesorge, who attended the crucial meetings, made sure that Ardenne was informed. In any case, in the spring of 1942 there was no sign of a waning interest in nuclear physics problems in Ardenne's institute.

From his point of view, it was only logical that Ardenne concentrated on isotope separation. He understood too little about the reactor theory to pursue these questions more intensively. In April 1942 he wrote a research report on the construction of an electromagnetic mass separator.82 Ohnesorge took this as an opportunity to urge Hitler to receive it. He wanted to convince Hitler of the need to promote nuclear physics research more.83 On June 9, 1942, one day after his 70th birthday, Ohnesorge was allowed to appear in the Reich Chancellery. Hitler received the jubilarian in a friendly manner. When Ohnesorge tried to seize the opportunity and wanted to urge him to promote nuclear research, Hitler reacted dismissively. He turned to the military officers present and said with an ironic undertone: "You see, gentlemen, my post minister, of all people, is offering me the miracle weapon that we need today."84 Ohne sorge was snubbed.

With his advance, Ohnesorge had achieved the opposite of what he actually wanted to achieve. Did Hitler already know about the results of the June 4 conference at this point?
Be that as it may, the wrong man had made a foray at the wrong time. Ironically, on the day that Heisenberg

and Döpel were able to prove neutron multiplication for the first time with their test arrangement (LIV) in Leipzig, Hitler rejected his Reich Post Minister with his nuclear project.

Hitler's mockery was rumored. In a small group, Max Planck, Hans Winkhaus and Erich Schumann discussed the prospects for uranium research.85 Winkhaus reported on Ohnesorge's bankruptcy and also wanted to know that in future Hitler would only allow projects that would come to fruition within a year.
“He knew that the Minister of the Post, Dr. In one way or another, Ohnesorge found out about the laboratory success of the Nuclear Physics Working Group and, after hearing some of the nuclear researchers involved who were also being questioned at the time by Field Marshal Milch, reported these things to Hitler. Hitler had decided that only those projects should be funded that would come to fruition in the current year.«86

Winkhaus suggested no longer speaking of the uranium project, but only of “isotope research for medical purposes”. Planck contradicted: “The prospects for the government agencies that approve the research funds [should] not be portrayed too pessimistically, especially since in principle (due to the measured neutron surplus) the release of nuclear energy is within the realm of possibility. It would be important to get more funds approved, at least to the extent that the scientists involved in nuclear physics could continue to work on their problems. The thread must not be broken, so that in peacetime the necessary experience would also be available in Germany.
However, he warns against making promises that the plans could still be realized during the war, especially since it is a question of solving very difficult technical problems. As a researcher, you should never agree to appointments.”87 After this conversation, Schumann must have felt confirmed in his decision to hand over

the uranium project back to the Reich Research Council. Erich Bagge explained in retrospect: »Schumann didn't believe that [...] He thought the scientists who did this nuclear physics were crazy and

therefore simply kept it away from Hitler. But certainly not with the intention of depriving Hitler of a miracle weapon, but in the opinion that that wasn't much.«88 It was only a matter of time before Diebner

was replaced as managing director of the KWI for Physics. Looking back, he regretted the HWA's withdrawal from the uranium project: »At this point in time, however, it would have been necessary to take the opposite decision; because only through the Army High Command was it possible to carry out the work on a large scale with the necessary speed.”89 On June 23, 1942, Speer gave Hitler a brief report on the conference.90 Speer followed Hitler’s exchange of

words as a guide Without worry and his conversations with the leading physicists. He had not received any signals from anyone that nuclear research had to be started as a large-scale industrial project. The project was not classified as directly decisive for the war. Despite this, Heisenberg and his associates retained their "uk" positions, continued to have access to scarce resources, and even larger budgets. Speer assigned the highest priority level to some projects of the Uranium Society.91

After the conversation with Hitler, Ohnesorge is said to have said to Ardenne that from now on he only intended to work on nuclear research within the framework of his department.92 Ohnesorge did not stick to this resolution for long. The Reich Post Minister returned from vacation at the beginning of September 1942, well rested and full of energy. Obergruppenfuhrer Berger wrote to Himmler: "[Ohnesorge] strongly urges to come to the Führer for the following reasons: a) According to his observations, America is currently bringing together all the professors of physics and chemistry in order to produce special achievements. He would like to make a brief presentation to the Fuhrer about this.'93 It is not known whether, in the fall of 1942, Ohnesorge managed to speak to Hitler again about nuclear research. However, the note shows one thing very clearly: the Reich Post Minister remained undeterred in nuclear physics research and at least guessed at its military potential.

In the spring of 1943, Ohnesorge invited several scientists from the Uranium Association to a conference in his ministry. Rooster and Hei

senberg spoke to officials, including Speer and the head of the OKH, Keitel. One of the participants, Hans Meckel from the scientific staff of the Kriegsmarine, described the details of the meeting: Heisenberg pointed out some unsolved problems, but hoped to be able to develop a bomb with unprecedented explosive power in one to two years.94 Suppose that that Meckel remembered correctly, then Heisenberg seems to have repeated his well-known argument, albeit with a concrete timetable, whereby he may have referred to the time after the reactor experiments had been successfully completed.

The Reich Research Council takes over the project

Finally, on July 1, 1942, the contract between the HWA and the KWG was officially annulled, and the KWI for Physics was once again under the sole control of the Kaiser Wilhelm Society should be at the top. Schumann had spoken out in favor of Walther Bothe as early as December 1941, which was initially generally accepted.96 Hahn, Laue and Harteck had concerns a few weeks later. They spoke up for Heisenberg to the General Secretary of the KWG, arguing with the reputation of the Nobel Prize winner. In addition, Heisenberg had been working at the KWI for Physics since 1940, even if only on a daily basis. After further maneuvers behind the scenes, the decision fell in favor of Heisenberg.

The KWG was unable to assert itself on a second important personnel issue. This concerned the post of head of the uranium association. After the HWA withdrew, the project was to be handed over to the Reich Research Council. Abraham Esau was being discussed as the new leader. Heisenberg disapproved of this proposal, but could not prevent it. The poisoned climate between Esau and Heisenberg was to determine the coming months.

Esau had already drawn up a tight schedule of work. He saw the next goal in improving the efficiency of the experimental set-ups in the reactor experiments. "In view of

However, given the current tense situation and the results so far, I feel compelled to demand even narrower objectives than before, in order to be able to carry out the tasks set as rationally as possible.«97 There was not much to distribute. However, he was able to build on remarkable advances in reactor testing. A lot had happened in Leipzig and Gottow in 1942.

The results of the fourth Leipzig experiment were better than those of all previous experiments. More neutrons escaped from the surface of the pile than were emitted by the neutron source. Döpel calculated the neutron increase to be three ten percent. This was a breakthrough. The measurement series of the LIV test were not yet complete when an accident occurred. On June 23, 1942, Döpel noticed that a stream of bubbles escaped from the bullet immersed in a water tank. It was hydrogen formed as a result of a chemical reaction between the uranium metal and the water. Consequently, the bullet had to leak.

Heisenberg happened to look in. Döpel indicated that he had the situation under control, after which Heisenberg left. He later returned to the laboratory, where the reactor had meanwhile become hotter and hotter. They decided to chisel the bullet underwater in several places to prevent a catastrophe. But it was already too late for that. The sounds in the pool of water increased significantly. Immediately everyone ran out of the room. Just in time. The experimental reactor blew up with a loud bang. Flaming uranium shot out and set the building on fire. The laboratory was destroyed, the uranium metal melted and much of the heavy water destroyed. As a consequence, uranium oxide was dispensed with and only solid uranium was used from then on.98

The fire of June 23, 1942 marked a turning point. Until then, Döpel and Heisenberg had set the pace of reactor tests. They had made a breakthrough with LIV. However, the fire and the loss of material threw them back. Since Heisenberg was now working as a director at the KWI for Physics in Berlin, his further reactor tests should only take place there.

Only after the war, with some distance to the events, did those involved realize that the world's first neutron multiplication had taken place in an experimental reactor in Leipzig. Enrico Fermi did not achieve a better result in Chicago until December 1942.

Immediately after the Leipzig accident, Bothe brought his institute into play for the next reactor tests. He planned a smaller experiment with about two hundred uranium plates and heavy water. He invited Heisenberg to participate." He reacted politely but firmly. All decisions about the distribution of material should only be made jointly, he wrote, which was a paraphrase for the fact that he claimed priority.100 Bothe had to realize that Heisenberg had major He had influence when he was there. Later, several employees from Heidelberg were temporarily ordered to Berlin. Bothe also advised the Berliners, among other things, on the design of the measurement channels. This also showed the superior approach of the experimental physicist. Where Heisenberg saw complicated problems, Bothe had practical ones solutions ready.

Diebner has the better concept

German uranium metal production peaked in 1942 and then declined. At that time neither the USA nor the Soviet Union had comparable technology for the production of metallic uranium. Nikolaus Riehl later showed his incomprehension about the lack of commitment: "I can't understand why they didn't even write a letter to Bormann or Hitler and said: 'Here we have the opportunity to make incredibly effective explosives Give us a level of urgency‹ exactly as von Braun did, who wrote such letters to Himmler.«101

Since the Leipzig experiments, Heisenberg saw himself on the right path. He advocated a model with alternating layers of uranium metal and heavy water. For him it was important that a theoretical evaluation of this construction could be carried out comparatively easily.102 The theoretician

was primarily interested in the elegant proof. Unlike Diebner, the practitioner wanted to get a reactor up and running as quickly as possible. In this respect, his removal from the post of acting director of the KWI for physics also had something good for him.
From then on, he and his young team were able to concentrate on their own experiments.

In the meantime, the KWI for Physics had switched to using metallic uranium powder, so that a relatively large stock of uranium oxide had accumulated at the HWA. Diebner was not above using the remains of the material that his colleagues had left him for a first experiment in Gottow (GI).103 Instead of heavy water, Diebner used paraffin.

It is not known who was the first to express the idea of trying a spatial point lattice made of uranium oxide cubes. The uranium should not only be surrounded by the braking substance in two, but in three dimensions. Shortly before the war, Joliot Curie had small blocks of uranium made for reactor experiments.104 As Diebner himself reported, the full significance of Curie's work was only recognized by the German occupying forces many months later. We know that Diebner traveled to Paris several times and sent some of his collaborators to Curie 's institute.105 It is possible that they received the decisive inspiration from the analysis of the French research documents. Be that as it may, the use of uranium cubes was a milestone in the history of reactor construction.

Hard work began for the Diebner Group in the summer of 1942. Bamag-Meguin supplied an aluminum boiler that was 2.5 meters high and 2.3 meters wide. This had to be filled in layer by layer like a honeycomb. A layer of paraffin was poured around a grid of wooden cubes. As soon as the paraffin had solidified, the molds were removed and the uranium oxide poured in spoonful by spoonful. The work had to be done in sweltering heat wearing protective clothing. One honeycomb layer was successfully completed per day. A total of nineteen layers and 6802 uranium oxide cubes went into the cauldron. About 4.4 tons of paraffin and 25 tons of uranium oxide were used for this. A 500 milligram radium-beryllium preparation was used as the neutron source

center of the container. The aluminum boiler stood in a concrete block four by four meters in size, which was filled with water as a reflector jacket. Finally, the test arrangement also included measuring devices developed in Gottow. The drudgery was worth it. GI gave a higher neutron yield than any previous experiment with uranium oxide.106 When the experimental results became known,

Heisenberg asked Höcker to evaluate the experiment theoretically. With his calculations, Höcker confirmed that the lattice arrangement produces more neutrons than a layered machine. Höcker's general investigations into the inner geometry of nuclear reactors were important for all further experiments.107 He calculated a spherical grid as the best variant.

The question of materials was again up for discussion. In order to be able to test his new idea, Diebner needed metallic uranium and heavy water. Without further ado, Esau ordered that Heisenberg hand over part of the 610 liters of heavy water available. It was made available to Diebner.

Experiment GII was carried out in the cold room of the Chemical Technical Reichsanstalt (CTR) in Berlin at a temperature of minus twelve to fourteen degrees.108 GIIa was anything but a practically usable device. But the effort was worth it. In the spring of 1943, the small reactor yielded one and a half times more neutrons than the best Leipzig experiment. Despite insufficient materials and the very modest size of the kiln, we were on the right track.

Attacks on heavy water production

While there were arguments in Berlin about the future of the Uranium Association, work on modernizing heavy water production in Norway had not yet made much headway. The conversion finally began in the spring and lasted until the autumn of 1942. In addition, the electrolysis plants in Saaheim and Notodden were also converted for heavy water production.109 At the same time, the construction of heavy water plants in the Reich area was also being prepared. This was only possible with the help of large companies such as IG Farben.

With a keen sense of new technologies, the management of the Leuna factory suspected that a new business area was opening up here. Director Heinrich Bütefisch, he was an honorary major in the Waffen SS and a member of the circle of friends of Reichsfuhrer SS Heinrich Himmler, wanted to be part of it. He commissioned his research director, Paul Herold, to approach Harteck with an attractive offer. In March 1942, Herold suggested building a high-concentration plant and a small hot-cold test facility in the Leuna plant. IG Farben wanted to bear all the costs for this. Of course, such an offer had its price: in return, they asked to be taught the basics of the “new way of generating energy.”110 It was decided that HWA and IG would work together to produce heavy water. 111 Did the heavy water project come into IG Farben's "stranglehold" as historians suspected?112 That would be saying too much.

The Uranium Association could not and would not do without the services of Germany's largest chemical company. Construction of the test facility began in the summer of 1942. After a year, the plant went into operation. Harteck immediately advocated a larger plant with a capacity of five to six tons per year. While he only had construction costs of 2.5 million Reichsmarks

Estimated, Bütefisch more realistically assumed almost 25 million Reichsmarks.113 Harteck was an excellent experimenter, but he had no idea about the cost planning for such a large project. The dispute over the costs escalated in the months that followed.

In the meantime, the British had set their sights on the Norwegian installations.114 A bomb squad was supposed to sabotage them. But the action ended in disaster. The British decided on a second attack. Now all eighteen cells of the enrichment plant were blown up and half a ton of heavy water spilled into the sewers. The attack on Ryukan in February 1943 was undoubtedly one of the most successful commando operations of World War II, even if its effect was overestimated. It only took six weeks for the damage to be repaired. In April 1943, the plant, complete with a second large washing tower, resumed production.

As a result, capacity continued to increase.115

Nevertheless, the attacks represented a turning point for the entire German uranium project. The military and scientists had to realize that such large facilities in an occupied country could not be completely protected. At a meeting with the leading scientists of the Uranium Association in May 1943, Esau decided not to continue the expansion of heavy water capacities in Norway.116 Instead, the construction of heavy water facilities in the Reich should be accelerated. Two large-scale plants based on the Harteck-Suess and Clusius-Linde processes and one or two high-concentration plants were up for discussion.117 Each of the research groups involved assumed that they had developed the best process.

There was heated controversy and a patent dispute between the Harteck Group and IG Farben. The construction of high-concentration plants was quicker to implement than the construction of large plants. However, investments in such plants only made sense if it was possible to procure preliminary products, i.e. lyes that contained at least one percent of enriched heavy water. For this purpose, Esau and Harteck traveled to Italy in mid-May 1943, but without success.118

In the summer of 1943, IG Farben's difficulties in Norway grew. Allied air raids had impacted ammonia processing capacity. The throttling of hydrogen electrolysis in Rjukan resulted in a corresponding drop in heavy water production.119 IG Farben, as the shareholder in the Norwegian plant, feared further attacks. It was about their money, because the damage caused in Norway was not compensated by the German state - unlike inland. While Harteck pushed for production to continue in Norway, IG Farben was no longer willing to do so.

At the end of September 1943 there was a meeting of the heavy water experts from IG Farben and the Uranium Association.120 Now the change of course on the heavy water issue was finally complete. Production in Norway was to be stopped and only preliminary products were to be delivered to Germany.121

Diebner and Heisenberg argue about reactor concepts

When Heisenberg learned of Diebner's success in Gottow in the spring of 1943, he dismissed his reactor design as "a somewhat improved apparatus of a similar kind." The breakthrough was to come with his stratified reactor and not with a competing project.

The open conflict was imminent. Heisenberg demanded a nuclear energy conference in which Albert Vogler should also take part. Esau then convened a conference on research policy issues for May 7, 1943. However, Vogler stayed away.

The most important point was the discussion about the reactor concepts. Diebner presented the results of tests GI and GII. He was clever enough not to attack Heisenberg head-on, and instead said that a comparison of the Gottow and Leipzig results was only possible to a limited extent given the different geometrical arrangements. Höcker may make additional comments on this. This put him in a tricky position, because he had spoken out in favor of the dice. His calculations were consistent and included a suggestion to use graphite instead of heavy water. Bothe also pointed out

ken that the Leipzig tests might have been evaluated too favourably. Heisenberg found himself subjected to cautious but clear criticism. Stubbornly he insisted. Höcker's calculations had not satisfied him. If the dice tests had produced more favorable values, the theory could not be correct, but there was no evidence for that. He wanted to continue his large-scale experiments with plates and vary the layer thickness.122 Bothe finally buckled. He agreed with Heisenberg's opinion, although he basically thought the cube arrangement was better.

Esau had to decide. There was a lack of material for the desirable simultaneous execution of tests in Berlin and Gottow, so he took tactics: »The general opinion was that a cube test is probably cheaper than a plate test. Nevertheless, I agree with Heisenberg and Bothe's suggestion that the semi-technical plate test be continued as planned.«123 Independent of this, cube tests were to be prepared and carried out in Gottow.

Heisenberg admitted that "a cube arrangement can give a slightly larger neutron multiplication than a layer arrangement," but then downplayed the differences in the results of the LIV and GII.124 He wanted to complete his layer experiments in order to gain experience for the construction of a reactor "In any case, the systematic shift tests should not be delayed by other tests."125 Heisenberg not only wrote to Esau, but also reported on the disputes at the conference in a scathing letter to Vogler.126 With the help of the Ministry of Armaments, Heisenberg finally sat down against Esau and knew how to discredit him at the highest level, which should ultimately lead to Esau's replacement.

From October 14 to 16, 1943, Esau issued invitations to another large conference.127 The conference was originally supposed to take place in mid-September, but Heisenberg asked for it to be postponed.128 To Esau's annoyance, neither Heisenberg nor any of his colleagues showed up. That was an open affront. But for Speer and Vogler, Heisenberg was the key man in the uranium association and no

the clumsy Esau. Little did he know that he was about to be relieved of his post.

Despite the lack of a Heisenberg group, the conference was well attended.129 The most important presentations were given by Bothe, Pose and Rexer. They concluded that of all the possible geometric shapes, the slabs were the worst. This is what Esau was waiting for. At the Auergesellschaft, he made sure that, in addition to the uranium plates for Heisenberg, dice for thieves were now also being manufactured.

A month after the conference, only Heisenberg and Döpel favored the layered arrangement. Even Wirtz had his doubts.130 Heisenberg recognized Höcker's calculations and Diebner's success, but he was reluctant to abandon the layered arrangement. Personal differences with Esau played an important role in his stubbornness, less so with Diebner. His group in Berlin has enjoyed top-level funding since the beginning of the uranium project. The best laboratories were available for Heisenberg and Hahn. Heisenberg's group received most of the scarce raw materials. Despite all this, an outsider was trying to overtake them. What would his promoters say if Dieb ner first managed to create a self-sustaining chain reaction?

Another, perhaps decisive, reason for Heisenberg's persistent adherence to the stratified reactor may be due to the fact that he only devoted part of his time to the nuclear energy project. He continued to teach at the university, gave numerous lectures at home and abroad and was active in other fields. He had made no independent contribution to the uranium project since his fundamental study "on the possibilities of technical energy production from uranium fission" in December 1939. His friend Carl Friedrich von Weizsäcker also turned his attention to other questions after the delicate debate about his plutonium theory and his appointment to Strasbourg.

Certainly Heisenberg would have been able to master the new reactor design and its theory. He didn't even try, however. It's debatable whether this was an unwitting misjudgment or whether Heisenberg was deliberately working slowly

in order not to advance on the "straight road to the bomb." His obstructive politics delayed the project by at least a year.

Before Esau could carry out another large-scale experiment, he replaced at the end of 1943.

Gerlach comes to the top of the uranium association

Esau's star finally fell when Speer turned his back on him. The armaments minister asked Esau's superior in the Reich Research Council, Professor Rudolf Mentzel, to look for a successor for Esau. In October 1943, Mentzel made soundings with the Munich experimental physicist Walther Gerlach.

This is a key figure in German nuclear weapons development. In the early 1920s, together with Otto Stern, he investigated the fundamental phenomena of quantum theory (Stern-Gerlach effect). Thanks to this discovery and his later work, Gerlach advanced to become an expert in the field of magnetic atomic moments.131 From 1929 he taught experimental physics at the University of Munich.

After the beginning of the war, Gerlach was mainly active in Berlin, where he worked in the scientific staff of the Navy.132 Gerlach was considered a man with diplomatic skills.133 Unlike his predecessors at the head of the Uranium Association, he was fully respected by the academic community. But there may have been other, less obvious reasons for the decision. Gerlach, who himself belonged neither to the NSDAP nor to any of its branches, maintained good relations with the SS through his brother. One year after the end of the war, Max von Laue described him as a “militarist and Nazi” who “wished Hitler victory and continued rule”. .134

Surprised by Mentzel's request, Gerlach asked for time to think it over and consulted Hahn and Heisenberg. Both advised him. Little did they know that Gerlach would devote all his energy to constructing a "miracle weapon". He officially took up his new post on January 1, 1944.

In most descriptions of German nuclear research, Gerlach is described as a character of integrity who came to the new post rather by accident and acted indecisively and weakly.135 This has to be contradicted. Gerlach certainly had the ambition to make the best of the task assigned to him.

Even on the outside, it set different accents than its predecessor. He felt like the "Kaiser of Physics".136 An "Kaiser" needed representative rooms, and so Gerlach moved into official and private rooms in the Harnack House. His right hand was Kurt Diebner, who had also acted as deputy under Esau and was the actual organizer of the nuclear research project. It must have been a satisfaction for Diebner to move back into the Harnack House in early 1944. A good eighteen months earlier he had had to vacate his office there.

The fundamental problem of the Uranium Association, its organizational fragmentation, remained unsolved even after Gerlach's inauguration. He had to listen to criticism about the little progress made by the uranium association on several occasions. He replied by pointing out that he regularly discussed the progress of the research work with representatives of the three branches of the Wehrmacht and the Waffen-SS. Gerlach rejected the formation of a "leadership staff" to control nuclear physics research and concluded with the sentence: "Any people and material that can be used in Germany for nuclear physics research will be used."137

Gerlach recognized that Diebner's group had a promising approach for a reactor and gave special support to the Gottow scientists. Paul Harteck also received greater influence than before. He pointed out to Gerlach that it was possible to operate a nuclear reactor with low-enriched uranium, and he also criticized his colleagues for underestimating his work.138 Reviewing Gerlach's activities, it becomes clear that that in the first few weeks in his new position he had shifted the center of gravity of the uranium project in the direction of Diebner's and Harteck's working groups. He believed these groups to be the ones most capable of getting a reactor up and running after all.

Gerlach's assumption of office was a turning point. Not just because now

»a cynic and idealist«139 came to the head of the uranium association, but also because a completely new direction of research, thermonuclear fusion, was secretly promoted.

The third attack on the Norsk Hydro

The renewed change at the top of the uranium association did not change the fact that the bottleneck in heavy water threatened to bring the entire uranium project to failure. The hopes of the Uranium Association now rested on IG Farben. Two test plants were under construction at the Leuna plant, a high-concentration plant and a plant using the Harteck-Suess process.140 For the Allies, of course, it was not the plants under construction in Germany that were the most important, but the fully functional capacities in Norway greatest threat. They therefore planned a third attack, this time from the air. The initiator of the company was the military leader of the Manhattan Project, General Leslie Groves. On November 16, 1943, 180 American bombers attacked the factory during the day. The bombs fell scattered and critical installations received few hits. The high concentration plant remained undamaged. However, since the power supply was cut off, the plant had to stop operating.141

The representative of IG Farben, von der Bey, and the Norwegian management agreed on December 10, 1943 to completely stop heavy water production. The heavy water supply for the uranium project almost came to a standstill. The Reich Research Council therefore decided to move the Norwegian high-concentration plants to Germany.

The cessation of production in Norway was intended to give the Allies the impression that the production of heavy water had ceased entirely in the German sphere of influence: »At the same time, the Vemork plant, with the exception of the high concentration plant, was to be rebuilt and an attempt made to build a high concentration plant at force the IG to at least purge the enriched liquors through a tacit agreement between Norsk Hydro and the IG of Nor-

to be transported to Germany."142 A deceptive tactic that the Allies fell for for a while.

The rest of the heavy water was also to be brought from Norway to Germany. Although the Germans did everything to cover up their plans, the preparations for the transport of the valuable material did not go unnoticed by the Norwegian underground. He alerted London. The cargo of 49 barrels with heavy water of different enrichment levels, totaling 610 liters, was to go by rail from Rjukan to Lake Tinnsjö. There the barrels were to be brought across the lake on a railway ferry. The Norwegian resistance decided to sink the ferry. On February 20, 1944, the "Hydro" ferry made its last trip.143 Plastic explosives and a timer had already been installed the evening before. The explosive charge exploded 45 minutes after the start of the crossing. 26 crew members and passengers drowned. The 49 barrels sank in the lake. A few barrels that were not quite full reappeared and were salvaged by German soldiers.

Were the attacks on the Rjukan-Vemork plant and the sinking of the Hydro ferry crucial to the war? That's debatable. After the war, Wirtz and Schoepke doubted that there were any barrels of heavy water on board the ferry. Allegedly, the Gestapo found out about the attack and chose a different route.144 Only casks with caustic potash were found on the ferry. Did the Germans really manage to fool the Norwegians? Hardly likely. The Norwegian underground had many eyes and ears and would probably have noticed an exchange.

Nevertheless, Wirtz's remark is not without significance. The four rescued and nineteen barrels from Saaheim came to Germany overland.145 These 23 barrels in total contained heavy water of different concentrations.
Part of this cargo was contaminated. It is not clear how much ultra-pure heavy water could be extracted from it.146

emergency programs

Now the German scientists had no choice. If they wanted heavy water, it had to be produced and concentrated on Reich territory. Gerlach and Harteck never gave up their hopes of producing heavy water, at least on a small scale. In February and March 1944 they again negotiated with Bütefisch.147 In view of the air raids, the construction of other large plants seemed unrealistic. Harteck therefore wanted to force the production of weakly enriched U235, since less heavy water was needed to operate such a reactor. Medium-sized heavy water systems should suffice.

Gerlach agreed with Harteck's considerations and approved the construction of a Clusius-Linde plant with a capacity of 1.5 tons per year in Munich and a low-pressure column for the distillation of industrial waste water in the Leuna factory.148 The cooperation with Linde was in Gerlach 's favour important. He and Harteck wanted to show IG Farben that they were not solely dependent on their goodwill. Work on the new plant had barely begun when the Linde plant in Munich was badly damaged in an air raid at the end of July 1944. Nevertheless, Linde tried to continue building the heavy water plant, but was not able to finish it by the end of the war.

What little heavy water was left was a precious treasure. Wirtz instructed his colleague Borrmann: “Do not hand over small amounts of heavy water, not even to Kummersdorf.”149 Hopes remained that the test facility in Leuna would soon be operational.

But on July 28, 1944, it received a direct hit and the test laboratory lay in ruins. With some effort, the system could have been rebuilt. But Director Bütefisch wanted nothing more to do with that.150

On August 11, 1944, a German dismantling commando arrived in Vemork and dismantled the Hydro's eighteen high-concentration cells. In addition, nine cells were expanded in Saaheim.151 Nine cells from the high-concentration plant as well as a Russian alternator were to be shipped to Berlin-Dahlem for the

KWI for Physics was created and a small-scale heavy water plant assembled from it.152 The main purpose of the plant was to further concentrate the already existing D2O . Although Harteck, as always, was optimistic and even the cautious Gerlach was carried away by it, the plant was never completed.1 « The remaining eighteen electrolytic cells were taken to Stadtilm in November 1944.154 Harteck and Diebner traveled together to the small Thuringian town, to see the status of the work.155 It is doubtful whether this high concentration plant was still being used.

The Leuna plant was not able to completely withdraw from heavy water production. Even before the destruction, the experts at the plant had expressed doubts as to whether the Harteck-Suess process was suitable for large-scale production.1S6 The Leuna management therefore favored a process developed by Karl-Hermann Geib. The Leuna factory brazenly submitted a patent specification for the high-concentration plant, which was largely based on the test results of the Hamburg group. Harteck was furious about this. In return, Harteck and Suess formulated their own patents. This cut the tablecloth between IG Farben and Harteck. Nevertheless, the emergency bound both parties together.

Harteck came to Leuna several times to advise on the construction of an experimental column for the distillation of ordinary water into heavy water. Geib stated: »He [Harteck] also discussed the view of the central office in Berlin that intensive further work - no matter how pointless it seemed for the war - was important for the reason that one day one would not start from a completely unknown weapon would be surprised by the enemy (USA) without even understanding how it worked.«157 To Harteck's surprise, the Leuna factory set up the test column in just a few weeks. The system was set up in the nearby Bitterfeld IG Farben plant south, which had largely escaped the bombings. The 24 meter high test facility went into operation on January 15, 1945.158 The hurry

The test facility constructed was not technically mature. A significant enrichment could not be achieved with it.

The heavy water emergency programs of May and August 1944 were no longer able to compensate for years of neglect. Although the heavy water did not dry up completely, mainly thanks to Harteck's efforts, the German uranium project never recovered from the blows against the Norsk Hydro. A total of only 2.5 to 2.7 tons of D2O was available for the German reactor tests.159 More than half of this, namely 1.5 tons, was used by Heisenberg for his last experiment in Haigerloch.

Uranium cubes instead of plates

After the success of the low-temperature test in the CTR rooms, Diebner's next reactor tests took place again in Got tow. Initially, the same arrangement was used as in the low-temperature experiment, except that heavy water now acted as moderator.160 In order to save paraffin, Diebner had the cylindrical aluminum container lined with wooden planks. There was just enough space to accommodate the small reactor structure—106 cubes of uranium on very thin light-alloy wires in heavy water. Each cube was exactly 14.5 centimeters from its twelve nearest neighbors. A paraffin cylinder on a steel plate served as the “lid”. 254 kilograms of uranium metal and 4.3 tons of paraffin were used as a reflector and diffuser jacket.

Even before the end of the experiment GIII a, GIII b was prepared. This in turn required six hundred liters of heavy water, but double the number of uranium cubes. But the Auer company had only delivered 180 instead of the requested 240 cubes. Improvisation talent was required again. Diebner had the missing sixty cubes made from the remains of earlier attempts.

For March 24, 1944, Gerlach convened a meeting at the KWI for Physics. He wanted to find out about the status of the production of uranium metal and then about the further reactor tests.

divorce A month earlier, Heisenberg had complained to him that Degussa had only been casting uranium cubes since November 1943. Heisenberg insisted that his Berlin group would continue to receive preferential delivery. In view of the limited production capacities, he questioned the Gottow experiments: "But it must be considered questionable whether two such large experiments can be carried out at the same time."161 Although

Heisenberg finally seemed willing to give up his layered concept, he was able to Gerlach could not bring himself to only make the scarce material available to one group. He continued to work in parallel. The Heisenberg group was still missing a few uranium plates and the Diebner group about 150 uranium cubes.

In the spring of 1944, the exact date is not known, the time had finally come in Gottow. In the GIII b experiment, 564 kilograms of uranium and almost six hundred liters of heavy water were used. The complex computational evaluation of the tests Diebner's group cheer. GIII b had produced a neutron increase of 106 percent, GIII a at least 59 percent. These values were well above all previously achieved results. Diebner's reactor concept had passed the suitability test. Looking back, he wrote: »Under the circumstances, there could no longer be any doubt that the enlargement of this arrangement must in any case lead to the self-exciting reactor. It was just a question of sufficiently increasing the amount of uranium and heavy water.«162 This was precisely the problem.

After the successful attempt, Diebner drafted a letter to his superiors, pointing out the feasibility of atomic bombs. Apparently there was a discussion in a small circle. It was advised against sending the letter.163 Another legend?

In any case, Diebner knew that a reactor could not only be used to generate energy, but also to produce fissile material for a bomb.

Heisenberg, whose institute had meanwhile begun relocating to Hechingen, received the results of the GIII experiment at the beginning of March 1944. He did the math and wrote a statement. He couldn't find any appreciative words for thieves.164 Quite

Gerlach reacted differently. He immediately went to the Ministry of Armaments. Since Speer could not be reached at the time, he spoke to Colonel Friedrich Geist, Speer's right-hand man on research questions.165 Diebner's group was now clearly ahead. At the KWI for Physics, on the other hand, there was still not much progress.

Between 1940 and 1942 the five unsuccessful series of experiments (BI to BV) were carried out in the "virus house" under the direction of Carl Friedrich von Weizsäcker and Karl Wirtz. Parallel to the experiments, the construction of an underground bunker laboratory was started under the leadership of Diebner and Pose. In the fall of 1942, the project received the highest level of priority and enjoyed Speer's personal support. The facility was equipped with all the necessary equipment and provided with meter-thick reinforced concrete walls for radiation protection. Even the heaviest bombing raids could not shake the bunker laboratory, it was both a test room and a shelter.

The bunker contained pumping equipment, a magazine for the heavy water tanks and ventilation to be able to suck out radioactive gases. The uranium could be transported by remote control. The reactor room was secured by double steel doors. A workshop was also available for processing the uranium metal and for analyzing the heavy water. The construction work was completed by the end of 1943. Only in the fifth year of the war could an experiment with heavy water be started in the Dahlem bunker laboratory.

Heisenberg commissioned Karl Wirtz to prepare and carry out the BVI and BVII experiments, in which the layered arrangement was still used. It turned out that the highest neutron multiplication was achieved when the plates were eighteen centimeters apart. Bothe had reached this result a year earlier with much simpler means.

Despite the best material conditions, the results of the Berlin trials lagged behind those in Leipzig and Gottow. In a letter to Vogler, Heisenberg attempted to sell the test series as a success.166 Vogler remained in favor of Heisenberg, but now pressed for results.

You can twist and turn: The Berlin experiments, for which most of the metallic uranium and heavy water available in Germany were used, ended in fiasco. The values achieved in Leipzig in June 1942 were not reached in the Berlin bunker laboratory, not to mention the significantly better values in Gottow. Only after this series of failures did Heisenberg and Wirtz adopt Höcker's theses on the geometry of uranium machines, which Diebner had already successfully implemented.

4. A previously unknown reactor experiment

The test laboratory in Stadtilm

In 1944 the war hit the German Reich with force. The Allies had long since won air supremacy over Germany. Their bombing raids on cities, roads and railways increasingly affected the German armaments economy. Hardly any big city could still work normally. The scientists of the Uranium Association also felt the effects of the air war. The physics institutes in Leipzig, Hamburg and Cologne were hit hard.

As early as the summer of 1943, the general administration of the KWG had prepared the relocation of its air-endangered institutes.167 The Hahn and Heisenberg institutes were gradually evacuated to Tailfingen and Hechingen in Württemberg. Heisenberg himself was in Hechingen from April 1944. The entire responsibility for the reactor tests in Berlin now rested with Wirtz and a few employees.

Harteck diverted from Hamburg to Freiburg and Kandern in the southern Black Forest. Clusius and his employees moved into accommodation outside of Munich, Kirchner went from Cologne to Garmisch-Partenkirchen, while Walther Bothe and Hans Kopfermann stayed in the cities of Heidelberg and Göttingen that had not yet been affected. The relocations secured the continued existence of the institutes, but slowed down and hindered work.

The research department of the HWA was almost completely relocated to Kummersdorf in August 1943. The PTR did not have comparable alternative quarters near the Reich capital. Esau used his personal connections to the Gauleiters of Thuringia and Silesia to find alternative quarters there for his institutes.168 Weida in Thuringia became the new headquarters. The small group of nuclear physicists, including Fritz Houtermans, came to Ronneburg.

The situation for industry was, of course, even more difficult. Large factories could not easily change their locations. For the

The Leuna works near Merseburg, Linde in Munich, Anschütz in Kiel, Degussa in Frankfurt/Main, the Siemens laboratory in Berlin and the Auer company in Oranienburg and Berlin were particularly important for the uranium project. All of these locations were among the targets of Allied bombing raids.

In March 1944, the Degussa works in Frankfurt were damaged in a bomb attack. Production could only be continued to a limited extent.169 After renewed attacks in the autumn, uranium metal production threatened to come to a complete standstill.
Therefore, the Reich Research Council ordered the relocation of the still intact uranium smelting furnaces. Shortly before Christmas 1944, they were transported to Zechlin, near Rheinsberg, to the Auergesellschaft staging post.170 In the spring, they were taken to Stadtilm in Thuringia.171 It was not until the end of 1944 that the new

uranium smelting furnaces in Berlin Grünau went into trial operation.172 Degussa then gave its orders one of the world's most modern plants for the production of special metals. The factory was able to produce almost a ton of "special metal" per month.

In mid-1944, Diebner strengthened his team. New additions were Fritz Rehbein, Oskar Pfetscher, the engineers Rolf Schlottau and Siegfried Hülsmann, and several craftsmen.173 Schlottau was hired by Gerlach to be responsible for all questions relating to the procurement of materials.174 He was responsible for the technical support of several production facilities distributed throughout the Reich. The name Fritz Rehbein will mean little even to those who are well-versed in the history of German nuclear research. At the end of October 1939 he had entered the service of the KWI for Chemistry. Just a few days earlier, he had received a research assignment from the HWA that was important for the war effort. Details about it are not known. In addition to the HWA, the Reich Air Ministry also acted as clients for Rehbein. These must have been important orders because his position in the UK was extended again and again. It is likely that Rehbein's experimental skills were decisive for his connections to the HWA.175

The relocation of the PTR to Thuringia ordered by Esau also had consequences for the Gottow research group. It should also be relocated to Thuringia. Thief should of

may not have been enthusiastic about this decision since he was in the process of preparing his most important reactor test. In the fall of 1944 he only sent an advance commando. Hartwig and Schlottau were to find a suitable alternative quarters.176 The choice fell on Stadtilm. The small town of six thousand inhabitants, located ten kilometers southeast of Arnstadt, had a large school building, the so-called middle school. This seemed suitable as quarters, especially as it had a stable basement in which the materials needed for further reactor experiments could be stored. In mid-September 1944, Gerlach had Telschow, General Secretary of the KWG, send him ten bottles of wine so that he could toast good cooperation with the "dignitaries from Stadtilm".177 On September 23, the mayor of Stadtilm and Hartwig signed a lease .

Temporary laboratories, offices and a workshop were set up in the school building and in a warehouse. Laboratory equipment and measuring instruments gradually arrived from Berlin and other cities. What was missing in terms of equipment, Hartwig tried to obtain with emergency certificates. Schlottau was also on the road almost non-stop. At the beginning of 1945 he received authorization from Gerlach and Graue as well as from the Reich Defense Commissioner for Thuringia to be able to travel back and forth between Berlin, Stadtilm and Haigerloch.178

At the end of 1944 parts of the high concentration plant dismantled in Norway were taken to Stadtilm. The laboratory was to be completed by Degussa's uranium smelting plant. In mid-March 1945, employees of the Auergesellschaft were still discussing the best location for the plants with Friedrich Berkei in Berlin. The casting plant was to be set up in middle school and the actual production was to be housed in a brewery cellar.179 After the war, the plans for expanding this cellar gave rise to rumors of an underground nuclear laboratory. However, these plans never came to fruition, let alone the start of production.180 The expansion of the temporary laboratory was slow, especially since the relocation to Stadtilm did not take place all

at once. A group of technicians and the scientists Czulius and Herrmann remained in Gottow.

Diebner himself stayed in Berlin with interruptions until February 1, 1945. In the meantime, preparations were being made in the Stadtilm laboratory under the direction of Hartwig for two smaller experiments: a “reactor with spheres and solid carbonic acid at a low temperature” and a smaller one with “uranium spheres and heavy water”.181 Diebner’s team had significant help with the concepts developed by Harteck.182 This work did not progress very far.

The residents of the middle school did not learn anything about the work of the scientists. You often saw them sitting and discussing in the inn "Zum Vaterland." Someone suggested that the closed guests were Bible Students. Since then, Diebner's people have only been known as the "Bible Researchers."183 Some of them lived with their families in the school, some in the inn. Diebner's family also found shelter at the school before they managed to find new quarters at Griesheim Castle, three kilometers away.184 Gerlach also stayed there on his brief visits to Thuringia.185 Meanwhile, the rest of Diebner's group struggled in Gottow and

Karl Wirtz with a few employees in Berlin for their reactor tests.

Cooperation between Harteck and Diebner

After the extensive destruction of the Degussa works in the fall of 1944, resuming production there was out of the question. Now Heisenberg's group had neither enough uranium plates nor enough cylinders. Nevertheless, Gerlach urged that a large-scale experiment be prepared using all available cubes.186 Gerlach feverishly searched for alternatives for the production of heavy water. With the help of Siemens and Paul Harteck's group, he had an easy-to-operate treatment plant for heavy water built in Berlin. Gerlach still wanted success.

For the BVIII experiment, about 680 uranium cubes with a total weight of about 1.5 tons were used in a lattice arrangement. But Wirtz didn't have enough staff: "The machine is coming

only slow progress. The metal isn't coming until today,' he wrote to Heisenberg at the end of January 1945.187 He pleaded with him to send some of his employees to Berlin. In view of the war situation, the emergency call went unheeded.

On the other hand, help came from Kummersdorf. Diebner sent five craftsmen to help set up the test setup in the bunker laboratory. Everyone knew they only had a few days left.
Gerlach, Wirtz and Diebner were already preparing to move the material. Wirtz expected physicists to be called up to the Volkssturm every day. On January 31, 1945, Gerlach ordered the work in Berlin and Gottow to be stopped. The scientists and the valuable material were loaded together with equipment and documents and driven to Stadtilm.

Wirtz's failure was foreseeable. The Berlin reactor tests were based on an inadequate concept. Paul Harteck should also have been aware of this. In the spring of 1944 he had again become interested in reactor experiments and ordered four hundred uranium cubes from the Auergesellschaft.188 The successes with his centrifuges gave him the chance to have a certain amount of weakly enriched material at his disposal in the foreseeable future. He wanted to use this for his own experiment. Typical Harteck, because he didn't think about handing over the weakly enriched U235, which he had won with great effort, to the Heisenberg Group.

Starting new experiments at a third location in addition to Berlin and Gottow could not be what Gerlach wanted. If he did not succeed in settling the rivalry between Berlin and Gottow, he at least wanted to prevent a further fragmentation of forces.

On March 22, 1944, Gerlach and Harteck drove to Gottow.189
The decision to combine Diebner's and Harteck's concepts must have been made on that day. Scientists from Siemens were now also indirectly involved in the preparations. Gerlach inaugurated Gustav Hertz.190 Werner Schütze, a Hertz employee, had already been measuring the heat emission of uranium two years earlier. Gerlach and Hertz agreed that Schütze should resume his experiments. That from

Schütze was given the title "Development of a method for detecting the decomposition of enriched special metal, the increase in temperature and determination of the detection limits."191 This was the first time a research contract was awarded for the heat generation of a reactor operated with weakly enriched uranium.192

Weakly enriched uranium

According to the current state of research, the German scientists have not been able to solve one of the most important problems on the way to the atomic bomb – the industrial production of U235. Shortly after the end of the war, Weizsäcker explained: “It was precisely the problem of isotope separation that we, partly knowingly and partly unknowingly, completely neglected, apart from the centrifuges.”193 A number of processes had been tried out on a laboratory scale, but did not manage to take the decisive step towards large-scale implementation. There was no German Oak Ridge, no big isotope separation factories.

Another reason why isotope separation was not pursued was that there were no specifications as to how much ultra-pure U235 was required. Heisenberg made no attempt to develop a theory for a U235 bomb, let alone calculate the critical mass. As already mentioned, a calculation of the critical mass only appears once in the research documents of the Uranium Association, and this only refers to a plutonium bomb, the production of which required a functioning reactor.194

For a long time, higher-level authorities were unaware of the explosive nature of the issue. In the summer of 1943, for example, Albert Vogler was completely uninformed about the significance of the uranium isotope 235. He asked Heisenberg: "What is the isotope 235 [...] about? If I remember correctly, a particularly large number of neutrons are released when it is shot at. But it is in uranium included only a very small percentage. Is that correct?”195 Heisenberg answered without clarifying the question. The problem of

He left isotope separation to others, but was not particularly interested in their work.

Several small research groups and individual scientists had developed equipment and processes for uranium isotope separation. Wilhelm Walcher in Kiel, Heinz Ewald at the KWI for Chemistry, Richard Herzog in Vienna and Manfred von Ardenne have been working on electromagnetic processes for isolating U235 since 1939/40.196 The electromagnetic processes use the principle that electrically charged particles of different masses have different curved paths through a magnetic field.
The magnetic field caused only the heavy mass particles to reach and collect on the other side of the chamber.

Walcher's separator had already proven its suitability before the war. In principle, uranium isotopes could also be separated with his device.197 Diebner recognized the value of Walcher's work and commissioned the construction of ten separators at the end of 1939.198 The project failed due to a ridiculous error for an industrialized nation: We had to pay for the construction of the separators vacuum tubes required. However, the first deliveries from Krupp were so defective that no usable devices could be manufactured with them. An energetic client would have dealt with the delivery company and demanded improvements or new deliveries. This did not happen because the HWA withdrew from the uranium project.

On April 9, 1943, Esau, Vogler and Mentzel decided to better coordinate the work of the KWG and the Uranium Association.199 Walcher then had to hand over the only functioning separator to the KWI for Physics. What happened to his device, who worked with it and how much uranium was enriched is unknown.

Gerlach focused on promoting the most advanced practices. These were Harteck's centrifuge technology and Bagge's isotope lock. Only these two projects received the highest priority. At the beginning of March 1944, Gerlach convened a specialist conference on isotope separation in Tübingen and a month later in Munich.200 He took up a suggestion from Harteck and Clusius to try a photochemical process and put together a working group.201 In this case, too, the events of the war quickly prevented

le progress. Significant results could no longer be achieved. Apparently, the photochemical process was not suitable for large-scale application. The situation was not much different with two other methods – Bagge's isotope lock and an apparatus developed by Korsching.202

The greatest hopes rested on Harteck. Although there were repeated setbacks, the Hamburg group was on the right track from the spring of 1942.203 In July 1942, Groth succeeded for the first time in slightly enriching a small amount of U235. Centrifugal technology worked! The HWA was enthusiastic.204 Once again it was Harteck who broke new ground. He thought about the results of previous experiments. What if you connected two centrifuges together and ran them at different speeds so that the pressure difference between the two was constantly changing? Harteck discussed this idea with his former collaborator Johannes Jensen and of course with Wilhelm Groth. On August 8, 1942, he drafted a patent. In the fall, Anschütz began building the first double centrifuge, the UZ IIIA.205 On November 24, 1942, Esau informed Hermann Göring about the importance of centrifuge technology.
He explained that such devices would have to be manufactured in large numbers as soon as their development was complete.206

Already in the first test with the double centrifuge on March 2, 1943, an enrichment of 5.2 percent was achieved with just a few grams of uranium.207 It was an instant hit Harteck proposed the construction of at least ten double centrifuges. The HWA agreed and promised six hundred thousand Reichsmarks in return. After the war, Otto Haxel spread the legend that Esau did not adequately promote the centrifuge project to prevent Hitler from acquiring uranium bombs.208 But Esau's correspondence with the Hamburg centrifuge experts proves the opposite.209 He urged progress.

Esau needed small amounts of enriched uranium to make these available to Bothe in Heidelberg for measurements and preliminary tests. In July 1943, Harteck then promised to deliver samples of ten to twenty grams of enriched uranium "in the next few weeks": "In the case of the small Kiel model of the ultra-

Centrifuge can tap 0.5 grams per hour, with the model in Freiburg around two grams per hour.«210 Gerlach supported

the centrifuge project to the best of his ability. In his cryptic notebooks there are several references to the Hellige company. Like Harteck, Gerlach apparently tried to calculate how much enriched material could be produced with the centrifuges. In his notebook he noted: "30 grams, 100 kWh, 21 Z [centrifuges?], yield 3,000 marks/year, 30 times 300 = 9 kilograms."211 It is almost impossible to get out of the hasty notes draw unequivocal conclusions from the numbers and keywords thrown. Nevertheless, it seems reasonable to assume that Gerlach calculated at this point how much weakly enriched material could be produced by Hellige in 300 days.

At that time, only the UZ I single-chamber centrifuge was in continuous operation at Hellige in Freiburg. It had been running since June 1943 and delivered 7.5 grams per day of 5 percent enriched uranium.212 Let us assume that the centrifuge had run uninterrupted for six months from July 1 to December 31, then during this period alone 1, 38 kilograms of uranium can be enriched by five percent. In fact, there were always interruptions due to material problems. Nevertheless, this extrapolation illustrates that significant amounts of uranium could have been enriched with simple centrifuges.

An important eyewitness to the production of slightly enriched uranium metal was the SD officer Helmut Fischer: "Once during a visit to the Physikalisch-Technische Reichsanstalt I was able to pick up a piece of 'special metal' that had a mixing ratio of 1:135 instead of 1 :150 corresponded. Such enriched uranium, with the mixing ratio gradually becoming more favourable, was by no means suitable for a bomb, but one could carry out experiments with it and obtain measurement data that could then be used to develop theoretical considerations about the course of a chain reaction.«213 In general, those responsible

waited impatiently more success stories from Hamburg. While Vogler asked Esau, the gray eminence of naval research, Admiral Witzell, asked Otto Hahn for information. Hahn's reply of May 4, 1943 was

revealing: »There is of course a great deal of interest in enriching 235, and work is being done on it in various places in Germany, as well as in the United States of America. To date, only gaseous compounds have been suitable for enrichment using centrifuges, which unfortunately do not have very pleasant properties. After all, success has already been achieved by Prof. Harteck in Hamburg, namely with an ultracentrifuge from Anschütz, the company that also supplies the centrifuges for the gyrocompasses. May I ask you to treat this information confidentially.«214

Harteck was therefore on a promising path when heavy British air raids on Hamburg made it impossible to continue working.215 He had alternative quarters prepared in Kandern, near the Swiss border.

On September 10, 1943, the experiments with the multi-chamber centrifuge could finally be resumed. Harteck immediately informed Diebner and later Esau as well: "An enrichment of about five percent was again achieved with a daily yield of 7.5 grams. If these results are extrapolated to the performance of the large double aggregate, there is justified hope that substance and selectivity are about as we had originally calculated and hoped, ie that more than twenty grams enriched by more than ten percent are produced per day.«216

The researchers fought doggedly for success. In the experiments, the centrifuge often ran for more than 24 hours. Suhr reported "that the overtired scientists were so exhausted on their way home at night that they walked and clung to their bicycles."217 After a few conversions, the UZ IIIA could be put into continuous operation in June 1944.218 After that, too the second improved double centrifuge UZ IIIB go into operation. How much enriched material was still produced with both ultracentrifuges is unknown. On the other hand, there is no doubt that it was produced. Where was the stuff?

Meanwhile, preparations were being made in Kandern for the installation of ten to fifteen double centrifuges. Harteck hoped that the construction work would be completed by the end of 1944 and that all centrifuges would be in permanent operation.

to be able to take drive. Professor Hans Martin from Kiel and later Konrad Beyerle joined the research group in Kandern.
Up to that point they had been working on the further development of centrifuge technology. Just a few weeks later, the tranquility in Kandern was over. On August 25, 1944, Allied troops liberated Paris and advanced towards Alsace. The front was getting closer. Again it was time to pack everything up and take it away.
Harteck chose Celle.219 But he didn't want to risk losing both ultracentrifuges at once. Therefore he only had one brought to Celle. The second working ultracentrifuge and parts for the others went to an unknown location.
After the end of the war they disappeared.

Harteck's group clung to their task with exceptional stubbornness. Somehow they managed to set up the UZ IIIB in Celle and put it into service in early February 1945. Thanks to numerous small improvements, they now even got a daily yield of fifty grams at fifteen percent enrichment.220 So theoretically it would have been possible to enrich one kilogram of uranium by fifteen percent in twenty days.

Only when British troops were a few kilometers from Celle on April 12 did the group give up. However, the enriched uranium was already gone. Several trips from Harteck to Gerlach and Diebner to Berlin and Gottow are documented, as well as trips by his colleague Jensen to Stadtilm and trips by Schlottaus from there to Celle. Klaus-Adolf Suhr kept a diary at the time, but there is no entry between the decisive days, February 24th and March 12th.221

We don't know how much U235 Harteck's group produced in total and what level of enrichment it had. Even among those in the know, the top-secret events were only hinted at. So we are forced to rely on statements made after the war. Those directly involved reported "several hundred grams of enriched or depleted isotope mixtures" that they had produced over the course of two years.222 Diebner confirmed this, albeit without mentioning where the material had gone.223 The statement "several hundred grams « is vague, it could also

have been a few kilograms. To emphasize it again: from mid-1943, Harteck's group was able to enrich uranium to around five percent with the simple centrifuge. A year later, an enrichment level of fifteen percent was even possible with the ultracentrifuges.

It should be mentioned at this point that centrifuge technology became established worldwide after the war and still plays an important role today in connection with the proliferation of nuclear technology.

An isotope separation plant of the Reichspost?

In addition to the Harteck group, Diebner's team was also in close contact with the Reichspost. At the beginning of 1941, Ardenne had discussed with Hahn and Heisenberg the question of how many grams of pure U235 were needed to set off a chain reaction.224 Ardenne took the view that a few kilograms of U235 could be obtained with the help of "highly sophisticated magnetic mass separators". First of all, he wanted to test the theoretical prerequisites and build a pilot plant. He entrusted his employees Fritz Bernhard, Karl-Heinz Riewe and Fritz Houtermans with these tasks. He was also commissioned to calculate the energy consumption during isotope separation. He solved the problem within a few months with the help of his friend Jensen. Ardenne's test facility had the great advantage over the other designs that the duo-plasma ion source he developed produced a consistently high ion density. To this day it is referred to as the »Ardenne spring«. In addition, his system managed with astonishingly little energy, an advantage that he particularly emphasized.

In March 1942, Ardenne presented the ideas of his research group in a secret special report “about a new magnetic isotope separator for high mass transport”.225 He had already acquired the necessary magnet. Shortly before the report was completed, there was a discussion with Heinz Ewald from the KWI for Chemistry about the advantages and disadvantages of linear and ring-shaped magnetic fields. Ardenne subsequently took over the boy's idea

Otto Hahn's employee to build a ring-shaped separating magnetic field, as it was easier to implement than his design. Ardenne wanted to use his pilot plant, calculated very optimistically, to produce 0.1 grams of highly enriched uranium 235 per hour. His institute was just waiting for the go-ahead to start building the isotope separator.

Ardenne's activities, like those of the Reichspost in general, were not appreciated by established nuclear physicists. They disliked the competition of these outsiders and tried to keep Ardenne out of the top bodies of physics. Apart from that, however, we cooperated with each other to our mutual advantage. For example, employees of the Kaiser Wilhelm Institute used the high-voltage system in Ardennes Institute. In return, he received knowledge of new research results.

Ardenne received a formal order to continue research into isotope separation in April 1942, only a few days after submitting his report.226 Construction of the pilot plant began shortly thereafter. It was clear from the outset that it should serve to prepare a larger system.

Parallel to the work in Lichterfelde, the Office for Special Physical Questions in Miersdorf also built an electromagnetic isotope separation plant. We owe references to Detlof Lyons, who did his doctorate under Werner Heisenberg in Leipzig in July 1941 and then accepted a position at the Office for Special Physics.227 However, a study he wrote did not mention Lyons, his report “about the velocity distribution and the spatial Distribution of fast neutrons in paraffin«.228 What did the Reichspost have to do with it? Previously there had only been sporadic relations between the Uranium Association and the Reichspost, but the war situation forced closer cooperation.
Tasks are now better coordinated. Among other things, in the spring of 1944, Gerlach commissioned the Reichspost to build a mass spectrograph.229

In addition to electromagnetic isotope separation, the Reichspost also attempted to gain access to centrifuge technology.
The Miersdorfers had been in contact with Paul Harteck on this matter since the spring of 1943 at the latest.230

Even in his memoirs, Ardenne was surprised that no one was interested in his electromagnetic mass isolator. His description does not appear to be completely complete, because on September 14, 1944, the Reichspost applied to the planning office of the Reich Research Council for the incorporation of the Ardenne research laboratory into the military research community.231 The justification stated that his institute only carried out “research work of absolute wartime importance”. .

Was Ardenne's design implemented on a large scale after all? After the end of the war, no isotope separation facilities were found. This story was not pursued further. Later it was said succinctly that the Ardennes pilot plant had great similarities with Oak Ridge. It is even said to have been more efficient than the American plants thanks to the »Ardenne spring«.

It was not until almost sixty years later that the history of the Reichspost's electromagnetic isotope separators took on a new meaning. While researching this book, Professor Schmidt-Rohr drew my attention to an interesting find near the spa town of Bad Saarow, sixty kilometers south of Berlin. Unusual concrete bunkers were discovered on a former Luftwaffe barracks site, which indicated that they were used for nuclear purposes. I made an appointment with Heiko Petermann and the Berlin science historian Dieter Hoffmann. After a short search we found two concrete bunkers. They are not far from the entrance gate, hidden under a mound of earth and under trees. The plants are about one and a half meters underground. The Reichspost proceeded in a similar way when building the cyclotron hall in Miersdorf. For reasons of radiation protection, this system was laid 1.3 meters below ground level.232 The circular concrete structures have a diameter of twenty meters and consist of a double concrete ring and a square extension measuring six by five metres. The concrete is massive. Cable ducts for electrical lines lead to the center of the circular system. We also discovered eight-inch pipes that were probably part of a vacuum system.

Could we have found the remains of isotope separation plants or just discovered unusual ammunition bunkers? We consulted experts. It couldn't be ammunition bunkers, they wouldn't have been laid out in a double ring. Maybe a warfare store? This was also denied by the experts. The narrow access area with the narrow flap-like steel doors would have hindered the transport. So isotope separation plants after all? Despite an intensive search, no reference to the »forbidden zone« was found in German and Russian archives. The site was occupied by the military from 1937 to 1994. Used by the German Air Force until 1945, it was taken over by the Soviet Army after the war. In the 1980s, medium-range missiles with nuclear weapons were stored here.

Then there was a vague clue. The »Grailer Report« can be found in the Museum for Communication in Berlin.233 It dates from August 1945 and served as an inventory. The assets of the Reichspost that still exist are listed here. It is also mentioned in passing that the office of the Reich Post Minister was relocated to Bad Saarow at the end of 1943. Remains of unfinished ministry buildings can still be found there today. Word in the Postal Ministry was that, fearing nightly bombing raids, Ohnesorge often went to Bad Saarow. However, to protect himself from air raids, he would not have had to dodge so far. There was probably another reason for his trips, because the small town was not only the reserve quarters of the Reich Post Minister, but also a military hospital for the Luftwaffe, built at the end of the 1930s, which, oddly enough, was designated as a special zone. The ring bunkers described above can be found less than a hundred meters from the hospital buildings. Had they been built as camouflage on the hospital grounds in a large patch of woods?

The ring bunkers of Bad Saarow bear a striking resemblance to Ardenne's design for a large electromagnetic mass separator.234 So there was more? In the absence of other documents, only a nuclear physical examination of the inner walls was able to provide further evidence. In fact, an examination of the concrete revealed traces of alleged

detect enriched uranium. If the bunkers in Bad Saarow are the outer shell of isotope separation plants, which in our opinion there is much to suggest, it still remains to be seen how much uranium was enriched there.235 According to estimates by the Heidelberg physics professor Ulrich Schmidt-Rohr, it might even be possible with a running time of one year, not much more than ten grams of highly enriched uranium 235 per plant should have been.236

Diebner's multi-stage reactor is running

The last Gottow reactor test was kept secret by those involved after the war. After the successful GIII experiment, Diebner knew that he was on the way to a continuous chain reaction. He foresaw the next steps, removing the plutonium produced in the reactor and using it in a bomb, although the processes for separating the plutonium had not yet been developed. After the GIII experiment, he had already considered informing his superiors that an atomic bomb would soon be feasible.237 Now he first wanted to crown the work of his group and be the first to achieve a continuous chain reaction.

The biggest problem for Diebner's group was still the lack of material. Less than a ton of heavy water was available. The calculations had shown that this amount would not be sufficient unless enriched uranium was used. It is possible that Diebner also used heavy paraffin. This had already been discussed in 1942, but rejected at the time.238 Heavy paraffin could be used to stretch heavy water.

The already used reactor vessel was used again. The uranium cubes from the GUIb experiment were still usable. In addition, there were more cubes that had been delivered by the Auergesellschaft in the meantime. A total of about 1.2 tons of uranium metal should have been available. In the last experiment - let's call it GIV - 520 cubes of uranium were packed into a sphere of heavy water or heavy paraffin. So far the tried and true pattern has been followed.

For the first time, Diebner had the chance to use several hundred grams of enriched uranium. He received the material from Harteck or the Reichspost, and he maintained close contact with both of them. The physicists at the KWI for Physics had already formulated the theory for a reactor operated with enriched U235 in 1940/41.239 They had come to the conclusion that the moment enrichment of the isotope U235 by around five percent possible, a uranium machine made from uranium and ordinary water using a spherical structure would provide power.

The idea of using a two-stage nuclear reactor for GIV was new.240 This means a facility in which a small critically operating central reactor (first stage) is surrounded by a larger subcritically operated external reactor (second stage). After the war, Diebner set out this principle in two patent specifications: “It is possible to dimension the first stage, which forms the central part of this two-stage reactor, with highly enriched nuclear fuel and a suitable braking substance so small that its volume is only a fraction of the entire two-stage reactor. This part of the reactor core can consist, for example, of a salt containing uranium-235, plutonium-239 or uranium-233 dissolved in heavy water or another liquid. The required amount of fuel needs under certain circumstances when using about a hundred liters of heavy water z. B. only amount to a few hundred grams if you use one of the above substances in pure form or mixtures of them in metallic form or in the form of chemical compounds as a fuel.«241 Pu239 and U233 were not available to Diebner in 1944/45, he but could a few hundred grams of U235
to use.

The first stage was surrounded by a larger subcritical reactor. The latter consisted of approximately two-thirds uranium oxide and one-third thorium. The arrangement worked in such a way that the reactor core served as a neutron source for the combustion of the fuel in the surrounding outer reactor part. The energy production of the central reactor core was low, but could be increased by the second stage.

The construction was approximately four by four meters

immersed in large basins, the water of which served as a means of braking and cooling. Under suitable operating conditions, such a two-stage nuclear reactor would have been able to produce appreciable amounts of plutonium. We do not know whether this was Diebner's goal a priori, but it can be assumed. How he came up with the concept of a two-stage nuclear reactor can only be guessed at. The decisive factor may have been the availability of slightly enriched uranium.

In the fall of 1944, preparations for the new experiment were complete. Diebner's employees began with the measurements. Values on the outside were good, but on the inside there was a significant spread that became problematic.
After completing the first series of measurements, Diebner wrote to Heisenberg on November 10, 1944 and reported on the different measured values in the outer and inner reactor area: »We attribute this to the small distances and the resulting difficulty, the indicators inside at the same places to attach back. We carried out the arrangement with 520 cubes that were attached spherically symmetrically. Since shifting the cubes created steps at the edge, we don't know exactly how best to set the integration limit.

But there are still many other questions that we would have liked to discuss with you.«242 This letter, found in a Moscow archive, is clear evidence of a previously unknown reactor experiment! An answer from Heisenberg is not known. Karl-Heinz Höcker's handwritten calculations for the last Gottow experiment are in the Stuttgart University Archives.243 He did not have complete insight into the experimental documents, but he must have known about the failure of the experiment and wrote about the “failure of the experiment”. He had an explanation for this: "It has so far gone unnoticed that the resonance capture is significantly changed by the H2O mantle surrounding the layer arrangement."244 A few lines later, the hastily drafted letter ended with a reference to a sequel that was still to be written of the report.

Allegedly, Diebner, according to the previous account of the participants ten, the reactor tests in Gottow were broken off in the spring of 1944.

But here we have evidence that the experiments continued and were about to succeed.

Incidentally, the reactor tests in Berlin and Gottow were closely followed by the highest authorities. Vogler offered Heisenberg every conceivable support in procuring the material: “I am also willing to talk to Minister Speer again, who, as you know, is extremely interested in the questions and addresses me at every opportunity to talk about this matter .«245 Speer and Vogler obviously had concrete hopes in the reactor experiments.

The reactor accident

Diebner's design of the multi-stage reactor was provisional. Due to a lack of time and material, devices were not used to be able to slow it down if necessary. There are no written

sources about further events in Gottow. Diebner's habilitation thesis, which perhaps also contained data from the GIV experiment, lay in a potato sack in the basement of his Flensburg apartment for a while after the war, until one day he destroyed it Crew Status Prohibited. Only after the lifting of the

research restrictions in the spring of 1955 were such topics allowed to be worked on again. Immediately afterwards, Diebner registered the first patent. Further patent applications followed in quick succession, including one on September 15, 1955 for the construction of a two-stage reactor.247 Where did his knowledge come from?

Only from international publications? Or were his ideas based on his own practical experiences? This question could not be clarified with the usual means of historical research.

The reactor test stand in Gottow was subjected to a thorough analysis in 2003. Surprising findings he brought a site inspection. This was a difficult undertaking, since the entire Kummersdorfer training ground, on which Diebner's test site was also located, was used by the Soviet army until 1994.

mee had been used. The remains of Diebner's complex had remained untouched for decades and had fallen into oblivion.
It was not until the late 1990s that the Potsdam historian Günter Nagel found the spot where the Gottow experiments had taken place.248 A comparison with old drawings and thorough measurements left no doubts.

Employees of the Federal Office for Radiation Protection examined the remains of the test facility and took soil samples within a radius of up to fifteen meters. Increased local dose rates were determined and U238 found. Further analysis revealed that U235 accounted for an astonishing 4.5 percent of total uranium activity.249 The material from Harteck's single-chamber centrifuge, which had been running since June 1943, had an enrichment level of five percent.
Taking into account tolerances and the time lag, it is plausible to assume that the U235 for the Gottow reactor was produced by Harteck's group.

During the first measurements in Gottow, however, no one asked how the material got into the vicinity of the reactor housing. During our discussions, Heiko Petermann came up with the idea of having the area around the former reactor site thoroughly examined again.
That's what we did: The soil samples, measurements and analyzes were carried out by physicists led by physicist Professor Arthur Scharmann from the University of Gießen and radiochemist Professor Reinhard Brandt from the University of Marburg.

The four by four meter concrete block was easy to find.
In 1944/45 there was a small crane between the cuboid and the iron pipe, which was used to lift the reactor boiler. In the direction of its former location, the outer wall of the concrete block shows significant damage at a height of around 1.5 meters; increased radiation levels were measured at this point.

The real surprise, however, came with the soil samples.
The ground in the crane area has burned out and is radioactively contaminated. The interior of the concrete block, on the other hand, showed hardly any measurable activity. How can this be explained?
Slag containing uranium, graphite and paraffin residues can still be found in the ground today, not in tiny amounts, but in total many kilograms. There-

none of us expected that. How did these materials get into the outdoors in the first place? An indication of an accident?

The material analysis provided the next surprise. The sintered ceramic chunks contained varying concentrations of radioactivity. The highest values came from the samples directly at the former location of the crane. U238 dominated up to a maximum of 2,700,000 Bq/kg, an extraordinarily high value.250 The radiochemist Professor Reinhard Brandt stated: »These uranium contents are orders of magnitude higher than what occurs naturally in soils. The uranium appears to be slightly enriched, which was also confirmed by an independent control measurement. Alpha spectrometry also confirmed the presence of significant uranium concentrations in soil samples and in paraffin lumps, and clear signs of plutonium in the concentration range of a few Bq/kg could be detected.«251

What statements can be derived from this with regard to the design principle of the reactor? Diebner's reactor was a product of ambition, need, time pressure, craftsmanship and inventiveness. We know from Diebner's letter to Heisenberg that the series of measurements was almost complete by mid-November 1944. Then the reactor must have been lifted out of the basin with a crane and set down to cool down.

What the scientists did not anticipate and what they could not know at the time was the continued neutron production in the outer region of the reactor. Since the reactor vessel now stood outside the basin, the water jacket as a neutron brake and cooling system was missing. A nuclear reactor stabilizes at a certain temperature, it "runs". So far the Heisenberg thesis had been confirmed. However, after about twelve hours, the neutron flow increases again due to the fission products that are produced, and so-called xenon-135 poisoning occurs.

Now the fact that no control elements were installed was paying off. In Gottow, the temperature must have continued to rise, the boiler must have burst at one point, some of the material must have melted and leaked. There is much to suggest that master craftsman Willi Hennig was badly exposed to radiation in the reactor accident. He was one of the longest serving employees

thief. On the evening of the unfortunate day, the exact date is not known, he returned to his family, suffered an attack of weakness and stayed in bed for several days. He returned hardly recovered: in early 1946 he had his family take him back to his former place of work in a handcart. He wanted to salvage material. Willi Hennig died on September 12, 1946.252

Diebner's deputy Friedrich Berkei may have been present at the accident and was also exposed to radiation. He died in September 1966 at the age of only 55 as a result of radiation sickness, although his family doubted this.253 The exact circumstances of his death can no longer be clarified. Even if there are no accident reports, the material can be analyzed hardly any room for other explanations – there must have been a reactor accident in Gottow at the end of 1944/beginning of 1945.

What was the neutron flux before the accident? The analyzes of the samples indicate that Diebner's experimental reactor GIV ran, even if only for a few hours or days. Then the reactor will have failed as a result of the xenon problem, which was still unknown at the time.254 So Diebner had made it and still failed. He had probably not achieved his main goal, the extraction of fissile materials.

Apparently there was not enough time to thoroughly remove all traces of the accident. How else can you explain that the remains of the accident, including irradiated material, can still be found around the test site today? The reactor boiler was also left behind. It was discovered by Soviet troops and inspected by Soviet nuclear physicists and economic officials. Their report states: »In the German town of Kummersdorf [...] a technical installation for the production of nuclear energy from uranium was found, which is now under our protection. According to the decision of the State Defense Committee, the said facility, together with raw materials and materials, will immediately be transferred to Laboratory No. 2 in Moscow brought.«255 What happened to it there is unknown.

The few scientists involved in the last Gottow reactor experiment apparently decided to remain silent.
At the beginning of April 1945, the research documents were destroyed or hidden. Why this secrecy? At GIV it was

Recognize the scientists' intention to build a breeder reactor. It was not about an energy-supplying machine, but about the production of bomb material. Admitting this would have meant destroying the legend of pure basic research in German nuclear physics. Added to this was the failure.

Farewell in Haigerloch

Some time after the concealed reactor accident, Gerlach stopped work in Gottow and Berlin. Together with Wirtz and Diebner he drove to Stadtilm on February 1st. All the Gottow and Berlin material was unloaded there, much to the annoyance of Wirtz, who wanted to continue with it to Hechingen. Indignant, he complained to Heisenberg by telephone. Gerlach asked Heisenberg to come to Stadtilm so that we could discuss how to proceed together.

On February 5, Heisenberg came to Stadtilm, accompanied by Weizsäcker. They demanded the Berlin material in order to be able to complete their experiments in Haigerloch. Heisenberg was right to point out that the preparations in the Felsenkeller were well advanced, while in Stadtilm there was little to be seen of an experimental reactor. Gerlach relented and assured a material transport. On February 23, Bagge and several trucks picked up one and a half tons of uranium cubes and heavy water, ten tons of graphite blocks and some cadmium metal and brought them to Haigerloch.256 Before that, on February 17, Gerlach and Sauckel had talked again . The Thuringian Gauleiter asked Gerlach what he wanted to do with uranium machines. Gerlach replied: "In my opinion, a politician in possession of such a machine can achieve anything he wants."257 He had already said too much. Sauckel now knew that Gerlach's scientists were working on something really big.

With a delay of around a month, Wirtz was able to continue the BVIII experiment in Haigerloch, which had been broken off in Berlin. At the end of February, the reconstruction of the reactor in the Felsenkeller began.

The experimental arrangement was an emergency product. Heavy water and a grid of uranium cubes were placed in a cylindrical container. The container was surrounded by a backscatter jacket made of graphite. There was water in the outer shell of the reactor vessel. Safety precautions were also dispensed with here.

Heisenberg and his colleagues saw themselves almost at the end of their many years of work. The scientists waited spellbound for the measurement results. The instruments showed a neutron multiplication almost tenfold. A very good result, but still not enough for a self-sustaining chain reaction. On March 1, 1945, Heisenberg sent a telegram to Gerlach and informed him of this interim result.258 Gerlach and Diebner then came to Haigerloch on March 5. While Gerlach drove on to Munich the very next day, Diebner stayed until March 10.2 *?

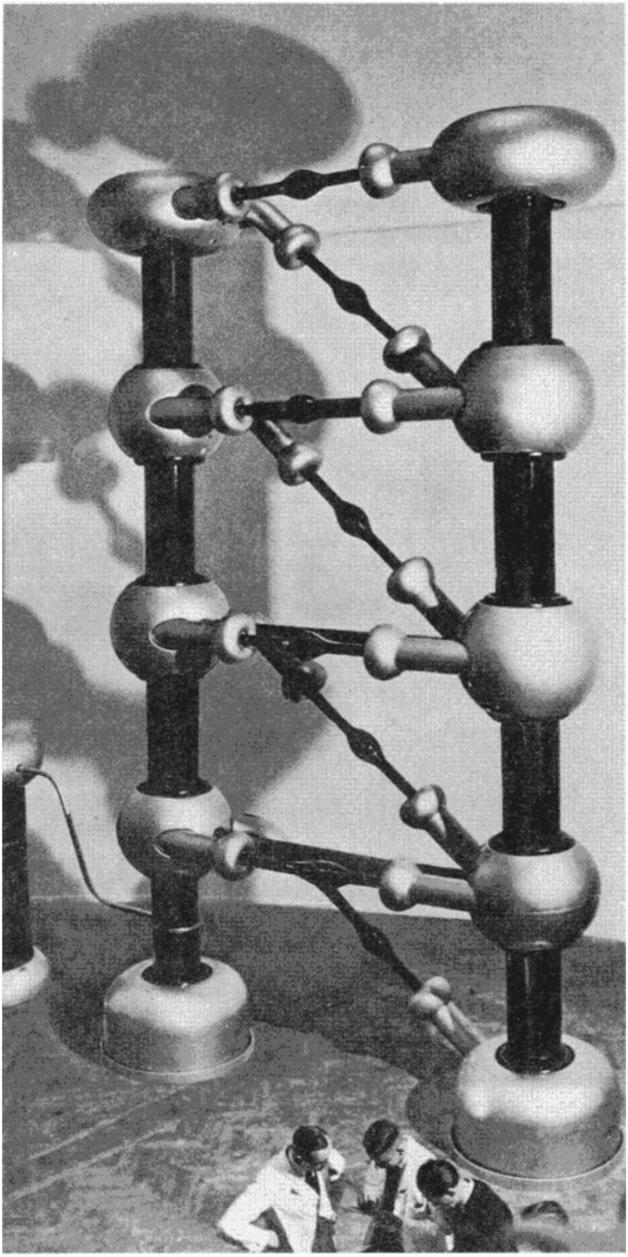
In order to achieve a self-sustaining chain reaction, either the experimental setup would have had to be changed from a cylindrical to a spherical configuration, or additional material would have had to be used. But that was in Stadtilm. Those involved did not consider converting the reactor.

The research group headed by Werner Heisenberg stayed a few meters from the finish line. Maybe this was her luck. Without a device to slow down the flow of neutrons, it might have been impossible to stop the chain reaction.

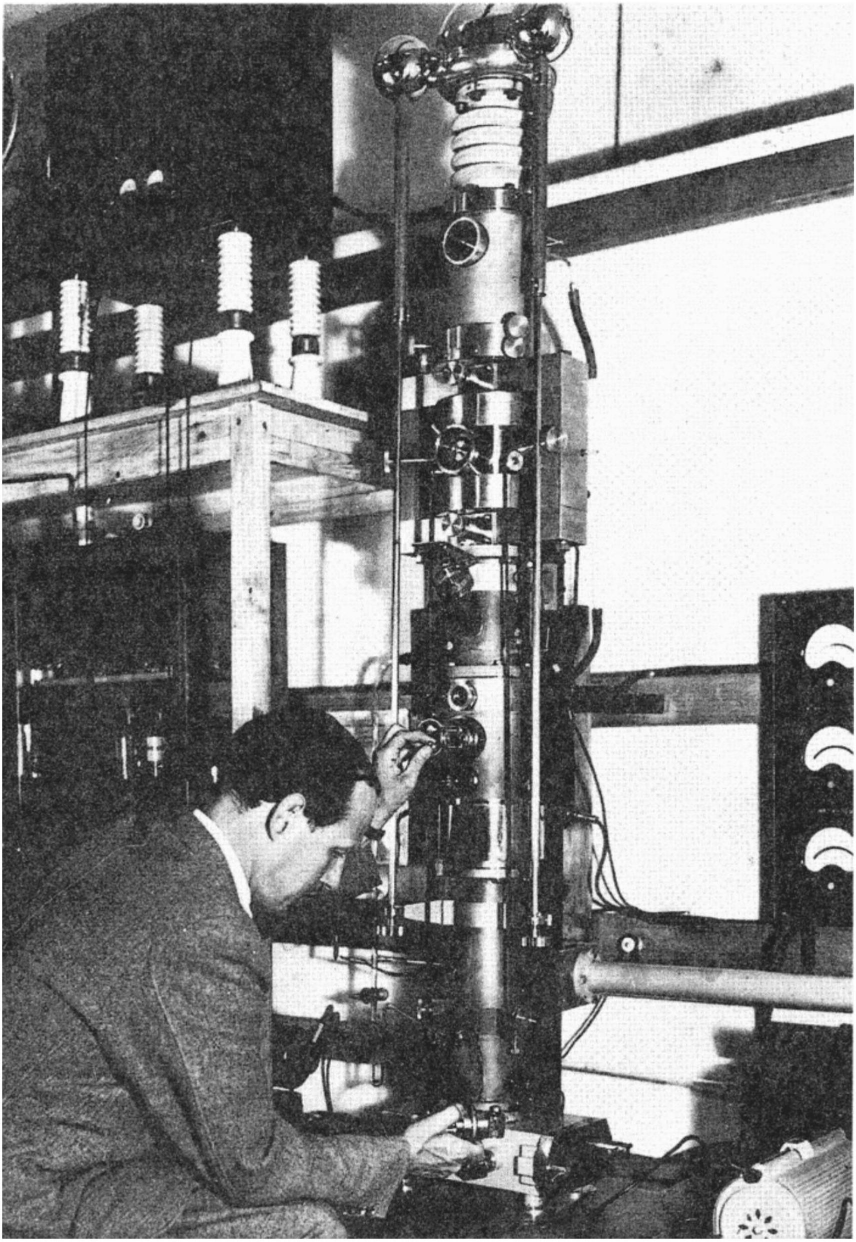
Otto Hahn

Werner Heisenberg

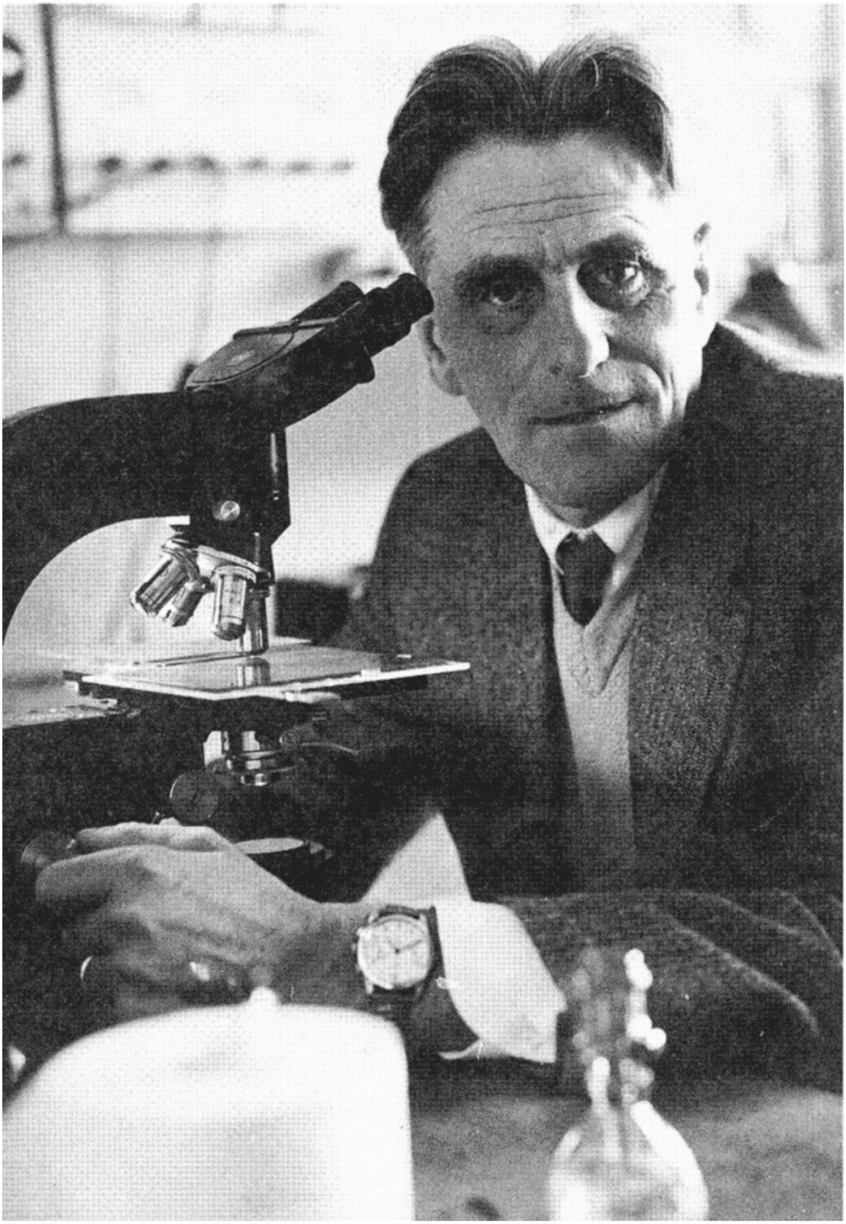
Carl Friedrich von Weizsacker



high voltage system

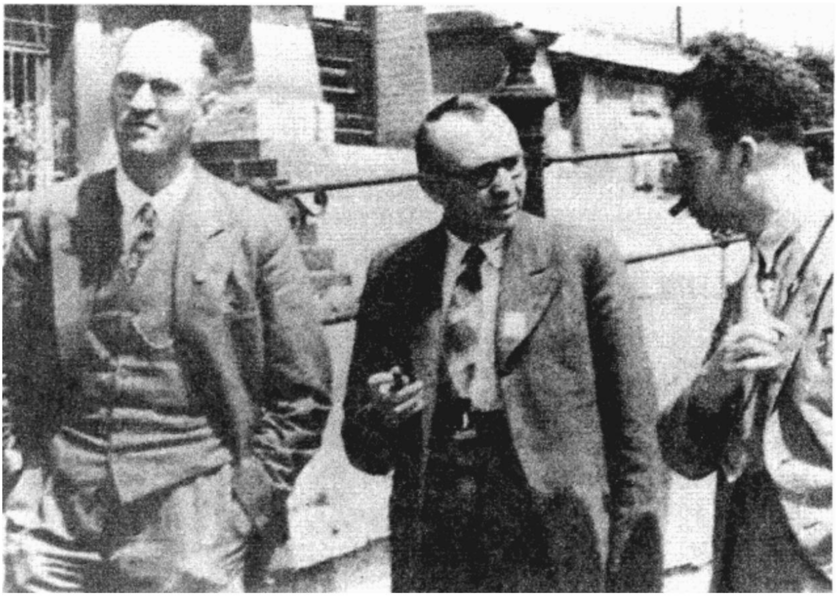


Manfred von Ardenne at his electron microscope



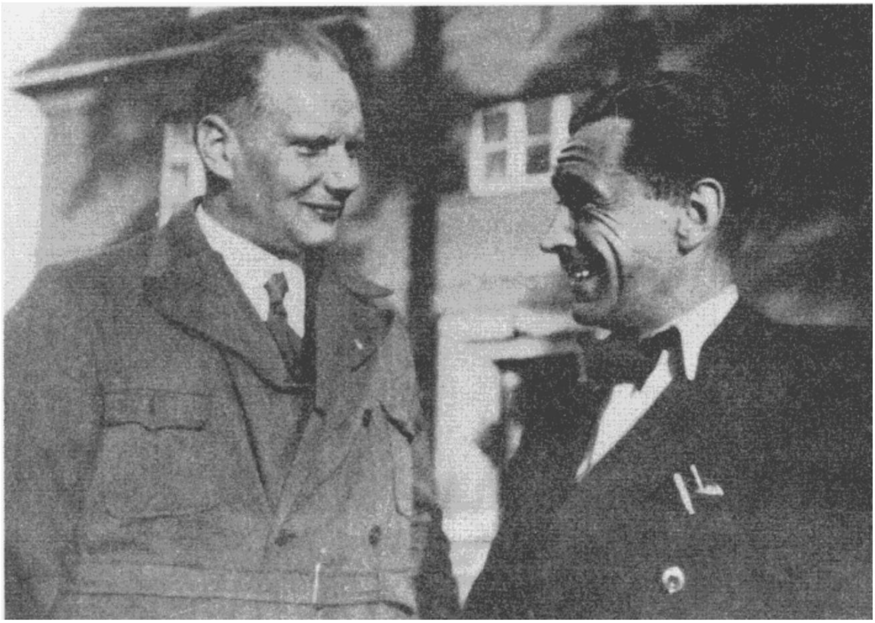
Friedrich Houtermans in the laboratory

Undersecretary Erich Schumann

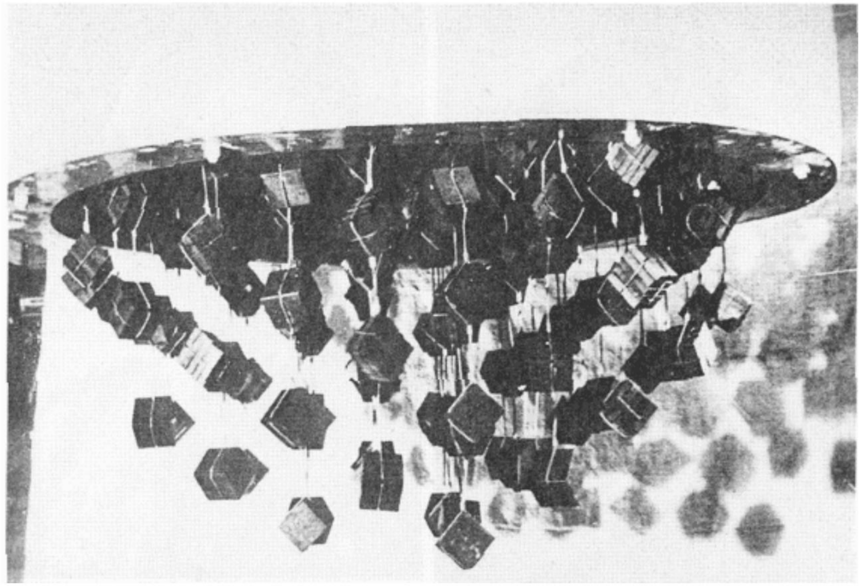


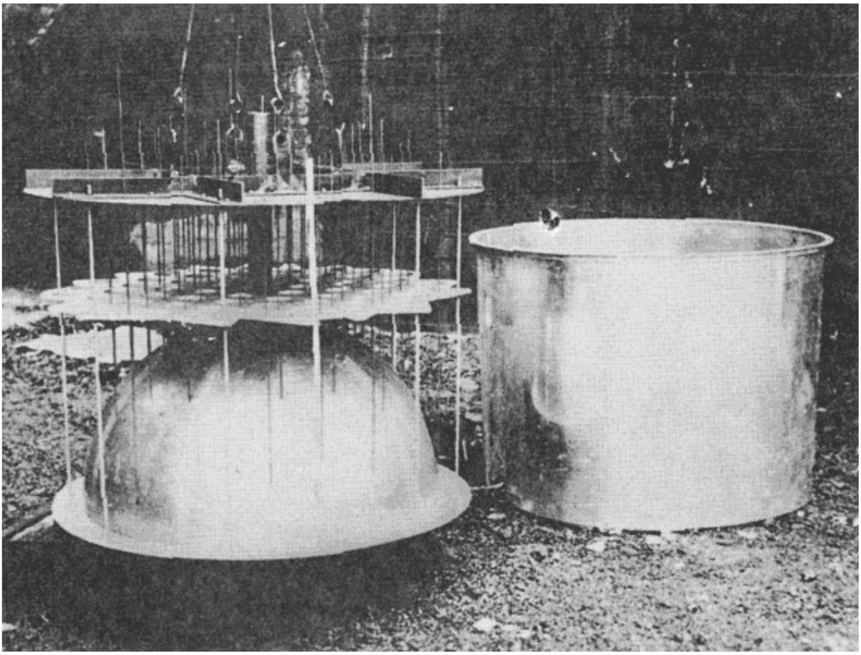
The three friends Heinz Pose, Kurt Diebner and Ernst Rexer (from left to right)

Paul Hartek

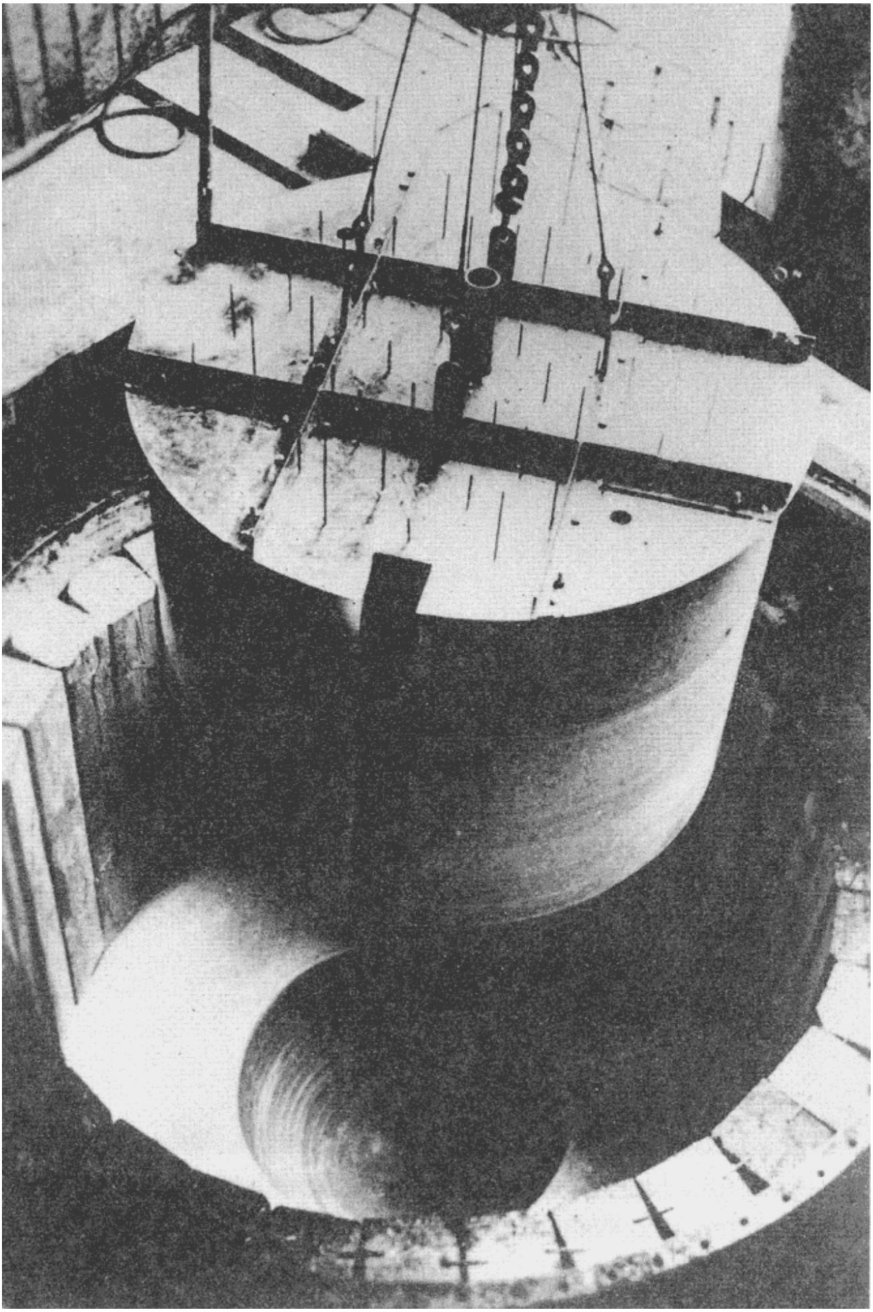


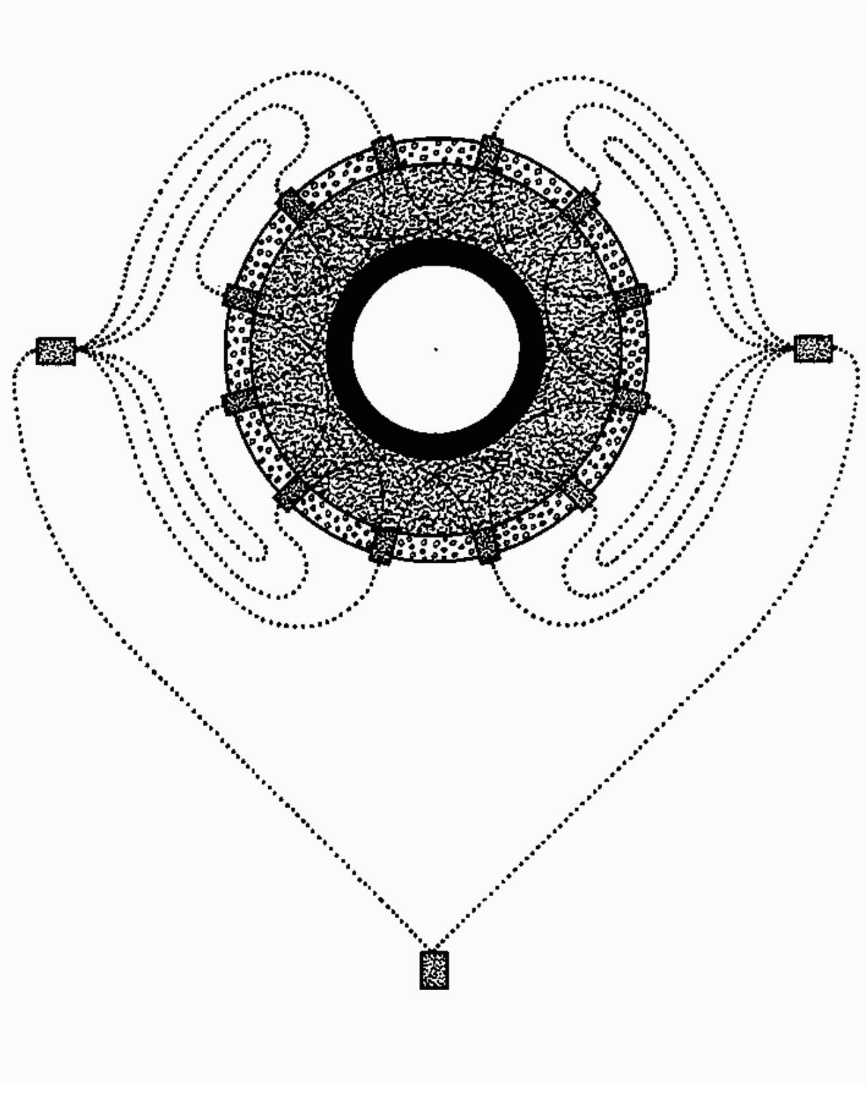
Walter Gerlach (left) in conversation with Paul Rosbaud





Diebner's reactor experiment G III (also following page)





Explosive physical arrangement to achieve high pressures and
Temperatures according to Walther Trinks (1944)

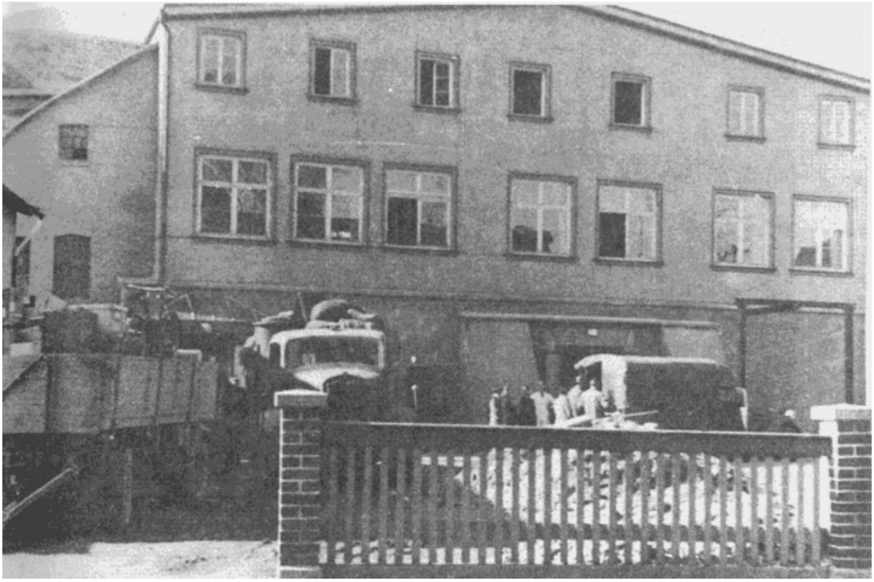
Otto Haxel with his secretary in April 1945 fleeing to Bavaria

Werner Czulius and master craftsman Willi Henning in protective clothing and with breathing apparatus. In the background the test facility in Gottow (probably 1942/43)

Albert Speer and Ehrhard Milch

Heinrich Himmler

Hans Kammler



The middle school in Stadtilm (1945)

Generals Eisenhower (centre) and Bradley (right)
at an open crematorium on the Hainberg, north of
the Ohrdruf concentration camp (1945).

THIRD PART

An alternative nuclear weapon concept

1. Nuclear shaped charges

Shaped charge research

In 1940, German engineering troops blew up the forty centimeter thick armored domes of the Belgian fort Eben Emael with heavy shaped charges. After this spectacular success, the Ministry of Armaments set up a »HohlCharge« working group.1 The »Panzerfaust« was one of the most important results of shaped charge research and was one of the outstanding weapon technology developments of the Second World War.

It has been known since the end of the 19th century that the geometric shape of an explosive charge has a decisive influence on the force of the detonation. Independently of one another, a German and an American producer of gun cotton found out that a hollowed-out explosive device has a particularly high penetrating power.2 It was not yet possible to investigate this phenomenon at the time. The measuring instruments could not withstand the extremely high temperatures and pressures during the explosion So the early experiments with shaped charges soon fell into oblivion. Until the Second World War, nothing significant was published on shaped charge research. Secretly, however, the Reichswehr had already commissioned a series of development work in this area. For example, a series of dissertations on theoretical problems of shaped charges were written at the II. Physics Institute of Berlin University under Erich Schumann.

The phenomenon of the shaped charge was also addressed elsewhere. A breakthrough came in 1935 from Franz Rudolf Thomanek from the Aeronautics Research Institute in Braunschweig. He developed the world's first hollow charge weapon, a 7 cm tank gun.3 The lining effect, also discovered by Thomanek in 1938, was decisive for further research. His revolutionary idea was to line the cavity of the explosive projectile with an insert. The penetrating power was thereby more than

doubled. The development of the "Panzerfaust" was then completed in the summer of 1942 at the HASAG company.4 Shortly after his second invention, Thomanek moved to Hubert Schardin in Berlin, the leading German ballistics expert, who headed the Institute for Technical Physics and Ballistics at the Technical Academy of the Air Force in Berlin-Gatow headed.5

The defense scientists examined a variety of shapes of shaped charges and varied, among other things, the insert material, wall thickness and explosives. However, they lacked a direct understanding of what happened during detonation, before the insert was deformed. In order to be able to record this process optically, the shaped charge body had to be x-rayed at the time of its explosion with an exposure time of less than one microsecond. This was not possible with the photographic processes that had been developed up to that point.

Shortly after Thomanek gave shaped charge research a new direction, the Siemens scientist Max Steenbeck, who was currently researching impulsive gas discharges, came up with the idea of investigating the X-rays emitted.6 It proved to be sufficiently intense , to expose photographic plates or film in a fraction of a second. Steenbeck contacted Schardin to clarify whether such a short and intense X-ray flash could be of experimental ballistics significance. Schardin was delighted.

In the years that followed, the Ballistics Institute and the Siemens research laboratory worked closely together. With the X-ray flash tubes, it was possible to record more than 45,000 images per second. Even higher frame rates were later achieved, according to various sources up to one hundred thousand frames per second. This made it possible for the first time to observe and analyze the jet formation in a shaped charge and the effect on an armor plate.7 Schardin confirmed the high degree of secrecy of this research after the war: "But not everything known to the responsible processors was recorded in internal reports either."8

In addition to the Technical Academy of the Air Force, shaped charge research was carried out at the German Research Institute for Aviation

in Völkenrode, northwest of Braunschweig. Here one dealt not only with questions of aerodynamics, but also in the broadest sense with gas dynamics and weapons.9 This research center was the most modern facility of its kind in Germany, probably in the world. It is characterized by the linking of wide-ranging basic research with innovative experimental and test facilities.

The competition from the Luftwaffe and Navy encouraged Erich Schumann to pay special attention to shaped charge research. In explosives physics he was one of the best specialists. Of course, he was even surpassed by one of his employees: Walter Trinks. After Schumann took over the management of army research, in 1940 Trinks was promoted to head of the department WaFIb »Explosive Physics and Shaped Charges«. By the end of the war, the group of scientists around Trinks had worked on at least forty secret patents on the topic of »shaped charge«.10

For his employees, Trinks was soon the “pope of hollow charges”. His calculation method for estimating the effect of hollow explosive devices was in amazing agreement with the experimental results. Schumann regularly summarized the studies of his employees on shaped charge research in work reports.11 These reports testify to the excellent level of research. A close associate of Trinks was Günter Sachsse. From the middle of 1942 he was officially a member of the staff at the Gottow research institute.12 Sachsse was Kurt Diebner's brother-in-law, and so the circle was closed that led to the combination of results from explosives physics and nuclear physics.

At least three places have been researching shaped charges. And despite the rivalries between the branches of arms, there was a lively scientific exchange.13 Since the studies were not published, it is difficult to clarify who came up with the decisive new approaches.

Around the same time that shaped charge researchers were gaining knowledge through X-ray flash photography, sensational advances were also being made in flow research. Among other things, she dealt with extremely high pressures and temperatures, which were also of interest for applied physics.

The theoretical work of Adolf Busemann and Gottfried Guderley in 1942 provided the impetus for a completely new direction in nuclear physics. Both worked at the aviation research institute in Braunschweig. They focused on shock waves and showed how pressure and temperature jumps in a small area around the convergence center could be achieved with shock waves should act like a "spark plug" in a fusion material.15

But how did the findings of the flow researchers get to the physicists of the weapons offices? The corresponding members of the Aeronautical Research Academy, Walther Gerlach and Carl Ramsauer, played a decisive role. The latter, a recognized experimental physicist and head of the AEG research laboratory16, approached Walter Trinks in the fall of 1943 and suggested “trying to initiate nuclear reactions with lithium using explosive explosives.”17 Ramsauer did not stop at his suggestion, but temporarily ordered one of his best employees to Gottow.

German scientists are working on nuclear fusion

The explanation of "starfire" has provided a fascinating brain teaser for physicists and astronomers around the world. Fritz Houtermans and Robert Atkinson finally presented the decisive approach to solving the problem in the morning year 1929.18 They put forward the thesis that a kind of nuclear combustion takes place in the fixed stars, in which hydrogen slowly converts into helium. In this process, enormous energies are released. In view of the extremely high temperatures that prevailed, the term »thermonuclear reactions« was coined.

In 1938, Hans Bethe, who had emigrated to the USA, and Carl Friedrich von Weizsäcker published fundamental articles independently of one another. They also listed the radiant energy of the stars

Nuclear fusion, i.e. the fusing of hydrogen nuclei to form helium. What was new about their theory was that, in addition to hydrogen and helium, they identified other elements that acted as catalysts for the solar cycle: carbon, nitrogen and oxygen.19 After the work of Bethe and Weizsäcker, the physics of stars was considered theoretical cleared.

The thermonuclear combustion of ordinary hydrogen is very slow. As a result, the stars shine for billions of years. In contrast, a thermonuclear weapon is said to burn very quickly. Experiments with tiny amounts of heavy water were made by British physicists Ernest O.
Rutherford and Mark Oliphant with Paul Harteck at the famous Cavendish Laboratory in 1934. With the help of a high-voltage particle accelerator, they hurled individual deuterons, called diplons at the time, against a target that also contained heavy hydrogen. They measured abnormally high energy bursts, a consequence of deuterium-deuterium (DD) reactions. They made a second discovery: the experiments had produced a microscopic amount of tritium, an isotope of hydrogen that was ideal for enhancing fusion processes. However, it was not yet possible to obtain significant amounts of this substance with the means available at the time.

Deuterium-tritium (DT) reactions do not require as high temperatures as DD reactions. But tritium had to be produced artificially. Until the early 1950s, nuclear physics assumed that the production of tritium was extremely complex and only possible in a reactor. Only then did American and Soviet scientists realize that tritium does not need to be bred, but that it can form itself in a mixture of deuterium and lithium under the influence of thermal and fast neutrons.20 Lithium is the lightest of all terrestrial metals. It has an atomic weight of

seven or six. Lithium 6 (Li6) only makes up 7.4 percent of natural lithium. When lithium is bombarded with neutrons, it breaks up into two lighter elements: helium, with two protons and two neutrons, and tritium, with one proton and two neutrons. Both compounds are gases and light

to separate from each other. Lithium 6 and tritium are important starting materials for nuclear fusion processes.

In Germany, lithium research had reached a high level before the war. One of the first physicists to deal with it was Heinrich Rausch von grape mountain. At best, his name is mentioned in passing in connection with nuclear research. He began his work on lithium decay after he was appointed professor at the University of Kiel in 1931.21 grape mountain was not involved in the work of the Uranium Association. However, his basic research into lithium decay inspired some of his students and other scientists to continue working on the problem. One of them was Ronald Richter. To this day, his achievements are highly controversial.22 Richter worked on lithium decay and deuterium-tritium reactions in the 1930s.23 In 1943 he worked for a short time at Ardenne and then at the research laboratory of the AEG transformer factory. He revised his theory of shock wave-induced nuclear reactions and devised a scheme of nuclear decay processes based on the fusion reactions of lithium and boron isotopes. The concept was to cause shock waves and trigger nuclear reactions by injecting lithium and boron into a highly pressurized deuterium plasma. In such a plasma, not only DD reactions take place, but also DT and TT reactions. All these reactions produce a spectrum of fast neutrons. The plasma zone should be surrounded by a beryllium reflector that stimulates neutron multiplication. If one induces natural uranium into such a plasma, then, as Richter pointed out, nuclear fusion could take place. There is no mention of the construction of a thermonuclear bomb in Richter's notes. He dreamed of one day being able to initiate controlled nuclear fusion in a reactor.24

Richter presented his concept to the head of the development and research department in the armaments ministry, Colonel Friedrich Geist. Apparently Geist couldn't do anything with the fantastic idea. He refused cooperation. However, it is quite possible that Geist gave Richter's research documents to other scientists for assessment.

We have dealt with Richter, although he was only a marginal figure in the German research context, because his research on the fusion problem is documented, whereas we know little more about other German and Austrian scientists than that they also worked on it.

At the beginning of 1941, an experiment took place in the courtyard of the Vienna Radium Institute, the consequences of which the physicists involved were not clear about.25 If this experiment had been successful, it would have meant the end of the Radium Institute, the surrounding buildings, and perhaps even worse. The scientist in charge of the experiment, Friedrich Hernegger, was to find out whether fusion of light nuclei could be initiated by means of spark discharge. That was the principle of the hydrogen bomb. Hernegger actually wanted to carry out the tests in his laboratory.
Colleagues from the neighboring institute, however, asked him to go out into the yard to be on the safe side. Luckily for everyone involved, his attempts were unsuccessful.

Nevertheless, only a few weeks later, Georg Stetter submitted a patent specification on the nuclear reaction with light elements.26 The OKH then asked the KWI for Physics for a statement. This was written by Karl Wirtz in July 1941: "It is probable that these nuclear reactions can never be used on earth to produce practically usable energy [...]

In addition, this patent always mentions high temperatures as being very important for the autocatalytic course of the suspected processes. According to its entire content, Stetter's patent relates more - in fact almost exclusively - to light cores. After all, the first part of Stetter's patent for ionized particles (charged nuclei), which are supposed to trigger nuclear processes at high temperatures, and also the example of the combustion of heavy hydrogen that is put forward seem to partly touch on the requirements of patent 662036.«27 The further course of the patent application is unknown.

Nuclear fusion was also considered at the HWA in Gottow.
Friedrich Berkei, Diebner's closest colleague, left a work notebook.28 In it he neatly listed DD reactions as well as Li6 and boron reactions. We put this formulary

well-known physicists, who reacted visibly surprised: »This is research on nuclear fusion. Were they that far back then?"29 Berkei's collection of formulas becomes even more interesting

if one compares them with work from later years.30 Berkei had already written down the crucial formulas for nuclear shaped-charge reactions plus a neutron source. So the HWA and, of course, the MWA knew what was important in fusion processes and wanted to use this knowledge to build weapons.

To what extent scientists from universities were also involved in this research cannot yet be said with any certainty. It is known that the physicist couple Noddack, among others, dealt with the decay of lithium.31 It remains to be clarified whether the research of the Noddacks had any connection with that of the weapons offices.

Alfred Klemm worked on lithium at the KWI for Chemistry

research and production of pure Li6. According to his own statement, he knew nothing about the client and its use.32 Carl Friedrich von Weizsäcker must also have been interested in lithium for a while. In 1940 he carried out a series of experiments on the destruction of light nuclei.33 However , he abandoned this line of research at the latest after moving to Strasbourg.

The circle of those who understood something about nuclear fusion must have been even larger than indicated here. The physicist Ulrich Jetter, who is best known to insiders, provided indirect confirmation of this in an article published in 1950.34 In it, he referred to the possibility that tritium can form spontaneously in a mixture of deuterium and lithium in a thermonuclear explosion. In 1950, no American or Soviet physicist would have dared to publish about this connection, which was only known to a small circle.

Compared to tritium-deuterium, a Li6-deuterium explosive had a decisive advantage. One was not dependent on a complicated cooling apparatus for hydrogen liquefaction. In the neutron flux of the detonation, the Li6 fraction forms im

Lithium metal automatically tritium. The groundbreaking aspect of lithium research was the fact that an alternative to tritium, which could only be obtained artificially and with great effort, was found.

Experiments with nuclear shaped charges

Let's have a look at the preliminary theoretical considerations of Trinks' group:35 In order for a reaction to take place between the atomic nuclei of light elements, they have to be brought close to each other. It is important to overcome enormous repulsive forces. This is only possible if the nuclei move towards each other at very high speeds. A sufficient density of the nuclei that react with one another and at the same time high kinetic energy of the particles is obtained if they are exposed to very high temperatures and very high pressure at the same time. Atoms then collide, and a certain percentage of them react.

When a normal explosive charge detonates, a shock wave propagates from the point of ignition through the body at great speed, up to eight kilometers per second. Behind the wave front, the plumes flow under very high pressure, up to 160,000 atmospheres. This can be significantly enhanced by shaped charge technology. Almost all of the energy of the shaped charge is concentrated in one jet.36 The thinner this jet, the higher the energy density. The decay of the explosive molecules causes the decay front to advance at supersonic speeds, and this leads to the development of extremely high pressures and temperatures.37 The energy is potentiated if the shaped charge body is encased in a steel jacket and has an insert such as beryllium.

Could the enormous concentration of energy in the jet of a detonating shaped charge be used for a nuclear effect? Theoretical considerations gave Trinks the impression that this was possible. He resorted to a suggestion made by Ramsauer, who shot a bullet into the muzzle of a second gun barrel in an experiment and thereby created very high pressures and

had reached the temperatures of the gas compressed in the second run. You could also direct two shaped charges against each other and place the substances to be reacted at the point where one beam meets the other (Guderley effect).38 If only four grams of deuterium could be converted into helium, energy would be released , which is equivalent to burning ten thousand kilograms of coal.

Trinks pursued these questions and attempted to calculate the temperatures that could be reached using the Guderley effect. However, the problem of the nuclear shaped charge could not be solved solely on the basis of theoretical calculations. Practical tests had to check the theory.

In October 1943, Schumann gave Trinks the green light for a series of experiments with which “atomic energy should be released through reactions between light elements”.39 In contrast to the complex reactor experiments, the shaped charge experiments were inexpensive. The fact that results could be seen immediately was probably even more important for Schumann. However, the arrangements did not work. Trinks now wanted to use hollow spheres made of silver. Since heavy water and a Geiger counter were also required, Diebner's department was consulted. The experiments had the express permission of Gerlach, who accompanied them scientifically.40

The HWA scientists undertook an experiment that seemed hopeless from the outset. They wanted to trigger uncontrolled nuclear fusion. We don't know much more about it.

All that has survived is an undated research report by the Trinks/ Diebner group, which was only one and a half typewritten pages long.41 However, this only reflects the early stages of the experiments. The simplest experiment had the following arrangement: a silver hollow sphere five centimeters in diameter and a wall thickness of two millimeters contained deuterium, which was to be compressed by a hollow charge. A hollow sphere twenty centimeters in diameter served as the explosive device. Multiple detonators were detonated on the bullet to ensure even compression.42 The silver was used to detect traces of radioactivity.

Theoretically, once the explosive is detonated, the silver should liquefy and shoot towards the center of the sphere. As the layer of liquid silver grew thicker, the inner surface accelerated faster than the outer. It would eventually converge over a tiny ball of compressed heavy hydrogen, which by now had reached very high density and temperature. All of the conventional explosive's energy was focused on the tiny amount of hydrogen at the center of the sphere. For a fraction of a second, the heavy hydrogen should be compressed under roughly the same conditions as at the center of the Sun. This could have resulted in DD reactions. However, the experimental arrangement devised by Trinks did not work.

Later, the scientists used cylindrical explosive devices twelve and five centimeters in diameter and ten and eight centimeters high.43 In the center of the base a small cone, 1.5 centimeters in diameter and three centimeters high, made of heavy paraffin was used as a deuterium carrier. If it had actually been possible to trigger a DD reaction, then neutrons and radioactivity should have been released in the process. To prove this, a silver plate was placed under the paraffin cone. In the first two attempts, there was practically nothing left of the silver indicator. The force of the explosion pulverized the material. However, the remains of the steel base did not show any increased radioactivity.

After these unsuspected failures, a new series of tests began with smaller explosive devices measuring five by eight centimetres. This experimental setup worked. Remnants of the silver remained. But they showed no radioactivity.

Trinks explained the failure with the insufficient swath speed and insufficient compression. At the end of 1944, he laid down his theoretical considerations on the experimental effects achieved up to that point in a habilitation thesis. Schumann immediately declared this work, entitled "Computational Investigations into the Effects of Explosives," a secret command matter.44

In an article from 1962, Diebner attributed the failure of the early attempts to the insufficient size of the arrangement: "The theoretical

Retic estimates resulted in a required sphere radius of ten meters and a minimum expenditure of explosives of several tons in order to achieve the set goal . In this case, not several tons but only a few hundred grams would be required.

The igniter problem

After the failed experiments with the small silver bullets, Trinks went on to larger orders. The decisive factor was the simultaneous detonation of the explosive charges. Trinks assumed that this was easier to do with larger bodies than with smaller ones. Therefore, his group is now experimenting with hollow spheres with the relatively large diameter of one meter and more. He was hoping for temperatures of around four million degrees at a pressure of 250 million atmospheres with the metallic ho spheres.[46] Schumann wrote a revealing letter about the experiments of the Trinks group in 1948 and assumed even higher pressures and temperatures: »The extraordinary compression of the matter and the enormous increase in temperature associated with it should be forced by the fact that the high Explosive-physically gained kinetic energy of a large mass carries over to a much smaller mass. The substance to be compressed, namely heavy water, was accommodated in a gaseous state in a metallic hollow sphere. The outer shell of the bullet was evenly covered with a layer of high explosive.

The difficulty now was to detonate the explosives simultaneously in a fraction of a second. After the explosive was ignited, high pressure was applied to the metal ball, which caused the metal to become plastic and accelerate toward the center. As a result, the trapped deuterium gas was compressed extraordinarily quickly and heated to very high temperatures.

This should reach temperatures of about ten million degrees at a pressure of about ten billion atmospheres. This could create the conditions for DD reactions and DT reactions. If, for example, water weighing around nine grams is completely converted into DD and DT reactions, an amount of energy of around 1019 is released. This roughly corresponds to the explosive force of 275 t TNT. Significantly higher amounts of energy can be achieved by adding other light elements, in particular lithium or boron.«47 A DD reaction was impossible to achieve in this way, that must have been clear to the

scientists. But Schumann also spoke of DT reactions and the use of lithium and boron as additional fusion substances.

A disadvantage of the large hollow bodies was their weight. A hollow iron sphere with a diameter of one meter and a wall thickness of just one centimeter already weighed 250 kilograms, plus an explosive weight of 1.5 tons with a twenty centimeter thick coating. Together with the external insulation, the total weight was around two tons.

Once experience had been gained with the large hollow spheres, attempts were made to use somewhat smaller configurations. The use of cylindrical pressure vessels proved to be particularly advantageous: "The pressure chamber consists of a cylinder with hemispheres placed on its base. The explosive surrounds the cylinder wall in the form of a double cone, along the base of which ignition occurs simultaneously. For this purpose, the explosive is encased in a jacket of inert material, which in turn is covered on the outside with a thin If the latter is then ignited simultaneously in the two tips of the resulting double cone, the detonation runs in two branches along the two cone shells without initially affecting the inner explosive device, because it is protected by the inert intermediate layers. When the two ignition branches meet, the inner explosive double cone is then intensively ignited along its base line, at which the inert covering is pierced. By choosing the symmetrical ignition

branching out from the two points of the double cone, greater uniformity is combined with a particularly powerful ignition of the main body. «48 The cylinder arrangement with shock waves directed against each other may have been superior to the spherical arrangement.

"A relatively high degree of simultaneity is achieved with the help of the so-called detonating fuse by using auxiliary ignition points, from which one leads equal-length pieces of this fuse with a constant detonation speed to the actual ignition point. The use of the usual union electrical glow igniters in the ignition points leads to unacceptable inaccuracies because of their indefinite delay time.

A time difference of a millionth of a second already corresponds to a path of the detonation front of around one centimeter [...]
A smoothing of the spherical detonation front running towards the center is possible based on the optics by using explosive lenses. Similar to the light beams there, a diverging bundle of detonation beams can be converted into a convergent beam by inserting either convex lenses made of a lower-velocity explosive or concave lenses made of a higher-velocity explosive between the explosive devices igniter and the hollow spherical surface to be accelerated.«49

It would have been ideal, in terms of the most uniform possible detonation process, if the explosive device had been embedded in earth or concrete. Of course, the experiments would then have been difficult to observe. Schumann therefore recommended detonating the explosive device a few meters above the ground. This is how the Americans and Soviets later proceeded with their first nuclear weapons tests.

The idea of the tamper – a very dense element that keeps the bomb together a little longer – must have been discussed as early as 1944. In the post-war period, Gerlach pointed out in a conversation with Schumann that the neutrons released in the deuteron reactions could be used to split U235 in natural uranium: "If, for example, the inner wall of the hollow sphere containing the deuterium was covered with a cladding [from cadmium? illegible] disguised, on the one

layer of uranium follows, then the neutrons are slowed down to thermal speed before they reach the uranium layer; there they are not caught by the U238, but can cause splits on the U235. One would then only have to try to prevent the neutrons escaping to the outside by means of a suitable shell on the outer surface of the hollow spherical shell, as in all cases in which neutrons that are released in the center are to be drawn in.«50

The neutron release from heavy hydrogen fusion is indeed tremendous. If only two grams of it were to be fused, 3x1021 neutrons would be released in a ten-thousandth of a second. A strong high-voltage source would take 350 years to produce this amount of neutrons.

The scientists under Schumann were probably no longer able to make the practical transition from the spherical to the cylindrical arrangement, as will be explained later. Apparently this was reserved for Gerlach.

Gerlach's double game

When Gerlach came to the head of the uranium association, there was no longer any talk of an atomic bomb. The uranium association dealt with basic research without direct relevance to the war economy. That should change under his direction. Gerlach stuck to the goal of achieving a controlled chain reaction in a reactor. At the same time, however, he was pursuing something else: He wanted to find out whether nuclear reactions could be triggered using shaped charges. This was clearly a military task. The Uranium Association wasn't good for that.

Gerlach started a double game. When he found out about the experiments started in Kummersdorf and Nienhof in autumn 1943 to trigger nuclear reactions using shaped charges, he took up the topic. To support this research, he set up a working group on the problem of maximum pressure at his institute in Munich. His assistant Duhm had been dealing with it for a number of years. He had a special device for pressures

up to fifty thousand atmospheres. It permitted electrical, thermal and optical measurements.51 Gerlach also involved his student Hermann Auer, who had just been appointed professor, in the high-pressure research. Also new in spring 1944 was the physicist Edwin Gora, a young Polish scientist who had worked for Werner Heisenberg in Leipzig in 1942.52 That this research must have been of particular importance can also be seen from Gerlach's

frequent trips from Berlin to Munich Conclude. Despite the air war, he made these trips, sometimes several times a month, and spent almost half of his term in Munich. In a list of the Reich Research Council from December 1944, his Munich project "Realization at maximum pressures and temperatures" is given the highest level of urgency without further explanation.53 Under

the work of Otto Haxel was supported.

Haxel had found important approaches with his working group under the OKM. One day he was asked by Admiral Rhein about the chances of success of fusion bombs using deuterium. According to Haxel, he reacted skeptically: "You would need a laboratory like that in the sun to reach the necessary temperature."54 Rhein and Haxel's immediate superior, Erich Buchmann, were not satisfied with this information. They consulted Houtermans, who, in contrast to Haxel, did not rule out the possibility of thermonuclear reactions being used in the German Reich in the foreseeable future.

The further course of things is not entirely clear. In any case, the Navy, under the scientific direction of Otto Haxel, began blasting tests using deuterium.55 Gerlach repeatedly met with him for consultations.56 In general , there was close working

contact between the explosives chemists of the Army and the Navy. Trinks and Buchmann also knew each other well.57 The Navy had an advantage thanks to the involvement of Otto Haxel and Pascual Jordan. In addition, Lieutenant Commander Professor Helmut Hasse, who headed the research department (FEPIII) of the OKM in Berlin-Wannsee, was also a research

The Grona company was founded in Göttingen in the summer of 1944 as a subsidiary of the Magdeburg company Schäfer & Budenberg. Schäfer & Budenberg specialized in the manufacture of special fittings. Its Goettingen offshoot had only one highly secret order – the manufacture of high-pressure bodies.59

We don't know what came out of the Navy's early attempts. Only a rough handwritten drawing has survived. After the war, British and American investigative teams learned little more than that the Navy had experimented with new types of explosives. They did not recognize the true background of the experiments. Otto Haxel told the Allies that he had recommended stopping the tests at Dänisch-Nienhof, which he did not expect to be of any practical use.60 This was purely a protective claim. Haxel reported that Esau allegedly warned him urgently at the end of 1943 not to work on a nuclear weapon. If Hitler found out about this, he would "stick Haxel and his colleagues behind barbed wire" until they made a bomb.61 Is such a warning from the head of the nuclear research project credible? Why did they both talk about a bomb when the Uranium Association only wanted to build a reactor?

Haxel was undoubtedly a brilliant physicist and experimenter. Fritz Houtermans was probably just as important as the idea generator for the naval group. He was working in Berlin on a secret assignment from the High Command of the Navy together with scientists from AEG.62 As an employee of the PTR, he was given access to irradiated material from the Paris cyclotron in 1943.63 In February 1944, Gerlach noted that Houtermans had approached neutron measurements APS should contact the Reichspost. He was supposed to carry out measurements with lithium and beryllium on the high-voltage system there.64 Gerlach was always active in the background. He wanted to use the shaped charge process for nuclear physics processes. With whom could he discuss this? It would have made sense to consult with Carl Friedrich von Weizsäcker or Werner Heisenberg.

However, both were no longer particularly interested in the research of the Uranium Association. Gerlach therefore did not bother her with this idea. Instead, he relied on his Munich employees. In early March 1944, he also sought the advice of Walther Bothe in order to think through the new research approach further.65 What would happen if you put a few grams of water in a shaped charge and ignited it? Couldn't this lead to thermonuclear fusion? Everything, according to Bothe and Gerlach, depended on whether the temperatures would be high enough to trigger the fusion process. Bothe thought it possible. The Gottow research group had already reached this point, but perhaps the talks with Bothe provided a new approach.

It was necessary to check the theoretical assumptions. Even before Bothe could complete his analysis, Gerlach had to go to Paris.66

In May, Bothe informed him of the results of his calculations. The temperatures required for a thermonuclear reaction cannot be achieved with conventional means. Did the experiments on nuclear fusion end with this episode, as all those involved claimed, if they were even asked about it after the war? A thought experiment, that's all it was. Therefore, historians did not pursue the matter further. There seemed to be no indication that the development of a fusion bomb was anything more than an obsession that faded away after a few weeks.

But the problem was not off the table, it was only now that research into the thermonuclear reaction was accelerated.

A secret meeting

In the spring of 1944, four men met secretly near Berlin. The two department heads of the Reich Research Council, Gerlach and Thiessen, met with Colonel Geist from the Ministry of Armaments. Thiessen's deputy, Graue, was also there.67 The four could have met in their Berlin offices, especially since they regularly met on business. However, they chose a place for their conversation

which they assumed they could speak openly about there. Thiessen describes the meeting as follows: “Away from Berlin, a large private estate had been claimed for the Speer Ministry. It was in a park by a large lake, and there one afternoon, evening and night the four of us had a meeting under the strictest confinement, that is, a table was set in a large meadow not far from the lake shore, on a lake shore free of reeds , and there they spoke openly about the fact that the war was lost and that one now had to consider whether and how one could preserve national substance – not nationalist ones.«68 As a young officer in the First World War and Fought in the Freikorps

in 1919.69 After joining the Reichswehr, he attended artillery school. From 1930 to 1934 he studied mathematics, physics, economics and general mechanical engineering at the TH Berlin, one of the most important training centers for the scientific and technical elite of German military research. He spoke several languages, including Russian. In mid-1940, Geist was transferred to the HWA and headed the ballistics and ammunition department. Colonel-General Fromm valued him: "A man of great caliber with drive and ideas, who can continue to be employed in such a way that he can be considered for the position of Chief of the Army Weapons Office at the appropriate time."70 As much as Fromm wanted to keep him, in On August 1, 1943, Geist was appointed head of the Research and Development department in the Reich Ministry for Armaments and War Production.71 Here he had to balance countless interests. Geist was Speer's representative in the Reich Research Council. He was responsible for the allocation of raw materials, materials and funds for uranium research and was also briefed on shaped charge research, betatron development and other classified work. He was a hard-nosed military man who harbored no illusions about the situation at the front We can only assume that he acted on behalf of Speer. Gerlach later referred to him as "Speer's right hand."72 What role did

Thiessen play in this group? In the 1930s he had risen to become one of the most influential science managers in the Third Reich.73 In the Reich Research Council ,

he took over the management of the chemistry department in 1937. Thanks to his networking in the highest circles of the armaments ministry, the SS and industry, his institute was able to lead a certain life of its own within the KWG. His most important contribution to military research was research on special warfare agents. Thiessen was a member of the Army's scientific command staff and took part in meetings on the problem of nuclear shaped charges.

Georg Graue, who had done his doctorate under Otto Hahn, was Thiessen's deputy at the KWI for physical chemistry. From May 1943 he worked in the War Economics Office of the Reich Research Council, where he was responsible, among other things, for assigning priority levels. This put him in a key position in armaments research.

According to Thiessen's memoirs and Grau's post-war statements, the four were worried about Germany's future. One goal of the meeting was to reach agreement on how as much of the scientific substance as possible could be preserved for the time after the defeat. Scientific know-how was seen as one of the few stable bases for reconstruction.

Thiessen stylized the meeting as a kind of "Catiline conspiracy."74 But the comparison is inappropriate. It wasn't about the preservation of the German Reich - this was not in their power - and also not to ward off a conspiracy, but to secure the personnel and material foundations of German science. The question of which powers to work with after the war was also raised. While Gerlach, Geist and Graue pleaded for the Americans and British, Thiessen saw the way out in cooperation with the Soviet Union.75 Whether Gerlach, Geist, Thiessen and Graue really saw the German defeat in spring 1944 as inevitable remains to be seen.

They did not refuse the regime. They held key positions in armaments research and directed the latest weapons development work. Important experiments have been going on in the Navy and Army for months. Gerlach wrote in a report at the end of May: »The question of generating nuclear energy other

Ways than through the decay of uranium have been tackled on a broader basis.«76 By this he meant the release of energy by means of nuclear fusion. As a consequence, it came down to building a bomb. Against this background, the conspiratorial meeting of the four men became particularly explosive. The question at stake was whether "we should still make means of extermination available to this state"77 or not. Their alliance of convenience lasted until the end of the war. Dozens of meetings with Thiessen, Graue and Geist were in Gerlach's service in 1944/45. Thiessen urged his son to contact Gerlach in the event of an unfavorable outcome of the war. He could absolutely trust him.78

2. On the way to the fourth »miracle weapon«?

miracle weapon propaganda

As long as the Wehrmacht was victorious by conventional means and subjugated almost all of Europe, there was no need for "miracle weapons." After the defeat near Moscow in December 1941 and especially after the lost battles of El Alamein and Stalingrad at the end of 1942/beginning of 1943, far-sighted military leaders suspected that the war could no longer be won, but they were careful not to say so openly. In 1943 the military situation seemed manageable. However, the Allied air offensive drove the German war economy into a cycle of destruction and reconstruction.
It was foreseeable that the Allies would sooner or later have to win the war thanks to their greater economic potential.79 After Albert Speer had become Minister of Armaments in the spring of 1942, the development of new weapons was accelerated. This was intended to offset the numerical superiority of the enemy.80 In addition to rockets, the development of jet fighters, submarines, remote-controlled bombs, heavy tanks, high-performance explosives and warfare agents was pushed ahead.

Groundbreaking projects have been started in all of these areas.
The biggest problem was the lack of time. There was still a long way to go before the new weapons could be mass-produced. In view of the setbacks on all fronts, the Nazi leadership relied on slogans to persevere and fueled vague hopes that new mysterious weapons were supposedly about to be used. The leadership of the Nazi state knew that the idea of revenge was widespread among large parts of the population in view of the Allied bombing raids, which were becoming ever more violent. There was also speculation about the imminent use of atomic bombs. The SD noted in July 1943: »Tales [are circulating] among the population about a 'new type of bomb' which is of such a size that only one piece at a time can be transported by a giant aircraft. Twelve such

Bombs constructed on the principle of atomic shattering would suffice to destroy a city of over a million people.'81 Every hint, no matter how small, was taken as confirmation of the suppositions circulating.

Goebbels mastered the art of deliberately spreading rumours. On the one hand, the regime needed miracle weapon propaganda to strengthen the will to persevere, on the other hand, the Reich Minister of Propaganda was well aware of the danger that the concept of retaliation should not be overused. "Retaliatory jokes" soon made the rounds, since the announced weapons were not to be seen. Eventually Goebbels felt compelled to slow down his propaganda machine. He was concerned with transforming passive optimism into an active will to persevere. The opportunity for this arose after the first aerial bombardment of London on June 17, 1944: “What began the night before last is the first turn of a screw – a screw that is being tightened more and more – as tight as is necessary is agile. Only the first rotation has been made in these days.'82 Schwarz van Berk, a senior employee at Goebbels, had the right to coin the term 'V-weapon' (weapon of revenge). Hitler and Goebbels immediately agreed to the new terminology. Just over a month later Goebbels announced in the »Völkischer Beobachter« that further »wonder weapons« would be used: »I would be ashamed to speak such language if the facts did not justify me. I recently saw modern German weapons that not only made my heart beat faster, but also stopped for a moment [...] The German inventor genius passed the acid test.«83

Again the propaganda overshot the target, disappointments followed. In mid-September 1944, Speer turned to Hitler and warned against exaggerated propaganda.84 Hitler allegedly agreed in private. However, he did not want to do without the wonder weapon propaganda. Winged bombs and rockets have meanwhile been successfully used with very limited effect. The still numerous Hitler supporters waited for further new weapons.

Only once was there a more or less direct reference to the work of the Uranium Association in the propaganda. At the

On August 20, 1944, the »Völkischer Beobachter« printed a comment on this by a correspondent from Lisbon, where Weizsäcker had given a lecture a few months earlier: »Here in Lisbon, information about the presumed deployment date of the new German weapons is chasing each other and is very much concerned with one Lecture that Prof. von Weizsäcker gave a few months ago on atomic physics in the hope of gaining insight into German intentions [...] Einstein's judgment was overruled after the Führer had declared: »The word has now German science‹«85

Hitler and nuclear physics

Hitler rarely commented on physics. His contempt for a science that, especially in Germany, was significantly shaped by Jews was well known. From this fact historians have deduced that it was ultimately Hitler himself who decisively impeded the progress of the Uranium Association's research Reich Post Minister expressed skepticism about his efforts in nuclear research. This did not mean that he rejected the research in general. Since 1939, Hitler had been informed roughly about the discovery of nuclear fission and the consequences. At first he did not attach any importance to Hahn's discovery. In the fall of 1940, he is said to have had a long, undated conversation about nuclear fission with his then armaments minister, Fritz Todt.87 At that time, no concrete information had flowed from the Uranium Association to the armaments minister.

The conversation between Hitler and Todt should therefore only have moved in general terms.

In October 1942, Hitler and Speer took a look at the building projects of the Reich Post Minister in Kleinmachnow.88 However , the Reich Post had nothing really presentable to offer in the field of nuclear physics. While carelessness with cyclotrons and high-voltage

engineering plants was courting Hitler's favor, the HWA had already withdrawn from the uranium project. There is no indication that the Uranium Association or the HWA had informed Hitler about the ways of building atomic bombs. Speer informed him on June 23, 1942, a few days after the decisive conference of the Uranium Association, that work on the use of nuclear fission for energy production would continue.89 This is the only documentary evidence that Hitler ever heard anything about the uranium project has experienced.

Hitler drew his knowledge of nuclear fission from utopian novels rather than expert reports. If one compares Hitler's behavior with that of Churchill, Roosevelt and Stalin, the difference can hardly be greater. The three Allies also initially had no idea what the discovery of nuclear fission meant, but unlike Hitler, they took the advice of scientists and followed their recommendations on this crucial matter.

The nightmare scenario drawn up by the writer Hans Dominik, that nuclear fission could not be controlled and would lead to a global conflagration, and even the end of the world, had taken root in many Germans. This idea also found its way into propaganda. "Das Reich" wrote on December 5, 1943: "For us, retaliation is not about a triumph of arms, nor just about a criminal court that our entire people are demanding today; an extreme, very drastic blow. Mankind is not far from the point where it can blow up half the earth.« Here we find both: the idea of the end of the world and the final annihilation. Incidentally, this fear also existed among Allied physicists.

Hitler believed in the use of rockets, but was able to recognize their limited military value as long as they were only armed with ordinary warheads. So he hoped for a combination of the missile weapon with a newly developed "super explosive." From the middle of 1944 he spoke about it in obscure allusions. So he has to go in

basics about the progress of the shaped charge researchers and nuclear physicists have been informed.

In July Mussolini traveled to Germany. On July 20, 1944, just a few hours after the assassination, he was received by an amazingly composed Hitler. After he had described the course of the assassination, he raved again about the new weapons.90 For the first time he also spoke of a new rocket, the A4, which had become known as the V2, with which he wanted to "raze London completely to the ground." The minutes of the conversation do not mention anything else. Chief Medical Officer Giesing, who treated Hitler on July 20, remembered the words a few hours after the assassination: 'In the shortest possible time I will use my weapons of victory, and then the war will come to a glorious end. The problem of atomic shattering has long since been solved, and it has been worked out so far that we can use this energy for armament purposes, and then the gentlemen will lose sight and hearing. This is the weapon of the future, and with it the future of Germany is also secured. Providence has already shown me this last way, and I know that the fundamental change will soon come.«91

A day later Hitler repeated his announcements to the Hungarian Field Marshal Miklos. He mentioned the production of new retaliatory weapons, up to the V4, and renewed his threats against London.92 V1 and V2 meant the flying bomb and the A4 rocket, and V3 probably meant Hitler's so-called high-pressure pump, a super cannon with enormous power Range. But what did he mean by the fourth vengeance weapon?

On August 5, 1944, Hitler also made suggestions to the Romanian dictator Marshal Antonescu about "new explosives, the development of which has been carried through to the experimental stage."93 The technological leap to the new super explosive is said to be greater than that from black powder to today's explosives. "When the Marshal replied that he hoped not to live to see the time when these new explosives, which might bring about the end of the world, would be used, the Fuehrer mentioned the further stages of development in this field foreseen by a German writer, the up to a point

would occur where matter as such would dissolve and then, however, bring about catastrophes of unimagined magnitude. In this research activity, two directions must be distinguished: on the one hand, the military evaluation of weapons that have already been perfected and fully developed, and on the other hand, the scientifically prepared, experimentally gradually tested and slowly carried out development of new materials up to mass production. In general, when new weapons are introduced, the principle applies that they can only be used immediately if one is absolutely convinced that they will end the war in one fell swoop. In the majority of cases, however, there is a danger that the opponent will use the same substances after ten to twelve months, so that such substances can only be put to practical use if one has developed a means of defence.'94 Then Hitler explained: "V1 was only one of four weapons that Germany would use. Another of these weapons, for example, had such a powerful effect that all human life would be destroyed within a radius of three to four kilometers from the point of impact had not forgotten his experiences from the First World War. At that time, the Supreme Army Command had repeatedly promised a turnaround

in the war from the use of new weapons, for example in the case of unrestricted submarine warfare and the use of poison gas. The Entente responded by tightening the naval blockade and using poison gas. The spiral of destruction continued without the hoped-for turning point in the war occurring. Hitler had learned that lesson.

He did not want to risk being the first to use weapons of mass destruction, primarily poison gas, because he feared devastating counterattacks by the superior Allied air fleets.

Still, he clung to the thought that one day he might own a weapon that would be crucial to the war. Hitler probably owed his idea of the effects of an atomic explosion to the writers Hans Dominik and Gustav Büscher. Büscher has the idea of the end of the world

by an atomic explosion: "But how dreadful it would be if the explosion of one atom followed that of the next, if it propagated from atom to atom! That would mean a world explosion, the end of the world!«96

Gerlach's Mysterious Journeys

Gerlach was aware of the dramatic deterioration in the war situation. If he still wanted to achieve something, he had no time to waste. His duty diary records numerous activities unrelated to the coordination of reactor experiments. Now it seems that the true purpose of some of his trips has been deciphered. Gerlach repeatedly visited the research facilities of the Navy near Kiel, the Wannsee Institute in Berlin and the Industrial Research Institute (IVN) on Lake Tollense, near Neubrandenburg.97 The centerpiece of the IVN was an artificial island on which a multi-storey command center with launch and control facilities for torpedoes. The scientific head of the research institute was Professor Ferdinand Trendelenburg, who was also head of department at the Siemens-Schuckert works.98 Gerlach and Diebner did not

come to Neubrandenburg alone to see torpedo testing. Walther Gerlach himself had worked in torpedo research for several years.99 He knew that the physicists around Trendelenburg could do more than design torpedoes. In view of the top-class names that were active in Neubrandenburg, it seems reasonable to conclude that this was the nucleus of Siemens' nuclear physics research. Gustav Hertz, for example, worked with Trendelenburg on the development of torpedo fuses. His team also included Max Steenbeck and Heinz Barwich. After the war you were among the most important German nuclear physicists. Steenbeck, who is credited with being one of the inventors of the betatron, and Barwich worked in senior positions on the Soviet nuclear project until 1955.

In the days following March 17, 1944, Gerlach received dozens of visitors in Berlin. On March 21st he was on a long

in the Reich Air Ministry, Haxel visited him two days later.100 Both conversations were probably related to Gerlach's next trip, which took him to Neubrandenburg. This date is underlined in the calendar, as is the company name Schering. On March 25, Gerlach and Diebner drove first to Schering's headquarters in Berlin-Wedding. The heavy water was obtained from Norway via Schering. Then the journey continued to Neubrandenburg. This trip gets an additional meaning if you not only accept the city of Neubrandenburg as your travel destination, but also a research or production facility in the vicinity, such as the small town of Anklam.

The following day, March 27, is noted in Gerlach's service calendar: "Speer - Weinpaket."101 It is quite possible that Gerlach from Germany's northernmost wine-growing region in Mecklenburg sent the armaments minister a small present. In general, this deserves to be recorded, since Gerlach's good relationship with Speer becomes clear here.

Of course, wine was not the reason for Gerlach's trips to Mecklenburg. After the massive bombing raid by the British Air Force on the Army Research Center in Peenemünde in August 1943, not only the production of the A4, but also parts of the development were relocated. The relocation locations included Anklam, Neubrandenburg, Rechlin and Sadelkow.102 After the Anklam airfield was also attacked by Allied bombers in August 1944, the research groups based there began to be relocated to Neustrelitz and Friedland. This is how the “Hans Lindemayer Research Center”, which was under the responsibility of Wernher von Braun, came to Friedland.103

Lindemayer's group dealt with the material testing of rocket parts. The technicians also received a special order. They tested the stability of aluminum balls of various sizes. These experiments had already begun in Anklam, as Ingeborg Brandt, who was sixteen when she was drafted into office work for the Lindemayer Group, recalled: “There was a kind of terrace in front of our hall. This is called the test stand. There was a sphere there [...] I myself estimate it to be 1.80 meters in diameter.«104 Irene König's description is more precise. she

worked as a telex operator in Anklam and saw the ball experiments several times: “Two aluminum balls were placed inside each other, one large and one small, and they steamed. At first I thought they boiled water in it. But of course I didn't dare to ask, it was all so secret. We were then transferred to Friedland after the bombing. Lindemayer went to Nordhausen and Johann Grüner took over the management of the group. In Friedland, the balls were spun at high speed in a large cauldron. At times, a mighty roar and thunder could be heard. The engineers then told us that they were conducting tests with pressure reducers.«105 It should be noted here that such large aluminum spheres did not exist in the known rocket designs.106 The vapor observed could have been dry ice vapor used to cool an unknown material in the sphere was used.

In addition to the Lindemayer group, a second research team led by Dr. Ing. Wolfgang Steurer to Friedland. He was considered one of the best experts in the field of materials testing and had an excellent knowledge of aluminum alloys.107 His group consisted of 24 scientists, technicians and support staff. When a special protective bunker was built for the scientists of the Steurer Group, this fueled rumors in the village. The assumptions ranged from the manufacture of special tires to rocket production and nuclear research.108 Employees in protective suits had been seen transporting materials and at work. Details were not disclosed.

One wonders what Gerlach and Diebner had to do with these research groups. And further asked: What did Wernher von Braun have to do with uranium research? For the time being, one can only speculate: the bomb casings for new types of experiments may have been manufactured in Friedland.

On February 20, 1944, as already described, the ferry "Hydro" was sunk on Lake Tinnsjö with the precious heavy water. Some barrels could be saved and were taken to Mirow. This small town is also near Neubrandenburg at a railway junction. were in the immediate vicinity

There is a large military training area and the Rechlin air force testing facility.109 The relocation of research groups to

Anklam, Rechlin and Friedland offers an explanation as to why the heavy water was brought to Mirow of all places. From there it was possible to get to the groups that were based in the vicinity in a short time. A few weeks later, the Reich Research Council discussed setting up a high-concentration plant for heavy water in Mirow, possibly on the military training area there.110 Gerlach later made several trips to Neubrandenburg and Friedland.

On March 31, Gerlach was in Pelzerhaken, a small port town near Kiel.111 There he met the scientific management staff of the Navy.112 The chairman of this staff was the electrical engineer Professor Karl Küpfmüller, head of communications technology development at Siemens' Wernerwerk & Halske and honorary professor at the TH Berlin.113 This deserves to be noted, since Küpfmüller, who often met with Gerlach in 1944/45, was a member of the SS with the rank of Obersturmbannfuhrer. The SS leadership must have been informed of the latest developments in weapons technology through the presence of their people in the scientific management committees. The command staff of the Kriegsmarine spent a day together on the Baltic Sea. Did you see an attempt to test the hollow spheres manufactured in Friedland on the high seas? This assumption is suggested by the memoir of Himmler's adjutant, Werner Grothmann.114 He had learned of a test at sea in which a new bomb was detonated on a pontoon. The unsuccessful attempt was observed by around twenty sc

breakthrough in autumn?

As we have seen, Gerlach promoted research into the thermonuclear reaction in the Navy, Army and Air Force Weapons Offices with all the means at his disposal. As in the case of the reactor experiments, so it happened

the experiments with nuclear shaped charges not to combine forces, but to work in parallel. Documents are sparse, since most of the documents were destroyed at the end of the war. From the works of the Air Force and Navy researchers only remained File fragments preserved.115 The research of the HWA group around Walter Trinks is better documented. I therefore base my statements on the construction of the nuclear shaped charges on the research reports of this group. The other groups may have arrived at modified solutions in detail, but the basic principles were the same.

By the autumn, work and preliminary tests by the various groups had progressed so far that the first major test could now be considered. It was unclear who should carry it out. If you look at the list of top-class visitors from all three branches of the Wehrmacht with whom Gerlach spoke in September 1944, it becomes clear that voting must have taken place that month. Among others, Gerlach met several times with the head of the HWA, General Leeb, the armory officer of the Luftwaffe, Field Marshal Milch, the head of research management of the Luftwaffe, Georgii, the head of research at AEG, Carl Ramsauer, and the research advisory board of the Navy.116

At his institute in Munich, the research project on the high pressures and temperatures had meanwhile made progress. On September 14, 1944, Gerlach received the head of naval research in his Berlin office. In his service diary he noted: "Buchmann, OKM, because of FEP."117 Erich Buchmann was Rear Admiral Wilhelm Rhein's deputy and the real head of naval research. FEP was the abbreviation for research, invention and patents. The next day Gerlach drove to the Wannsee Institute with SD officers Fischer and Spengler. Another important meeting with the researchers of the naval group took place on September 19, 1944. This time Buchmann brought his best scientists Haxel, Bauer and Ertel with him. The conversation lasted almost the whole day.118 Just a few days after the

marine researchers, the HWA scientists presented their proposals for the release of atomic energy through fusion to the HWA Research Advisory Board.119 Minutes of these

Unfortunately there are no such important meetings.120 However, we know from Schumann's memories that Leeb, Planck, Esau, Thiessen, Schumann, Kadow, Basche and Trinks were present at one of the two meetings. Spokesman for the HWA research group was Schumann. He presented the ideas developed by Trinks on the »release of atomic energy by nuclear synthesis in light elements«. In 1949, Schumann wrote down the status of the work achieved by autumn 1944. Due to the explosive content, his manuscript was never published and disappeared into a private archive.

Among other things, Schumann reported on various material tests. They served to determine the optimum shaped charge shape and wall thickness. In order to achieve high accelerations on the inner front, it proved advantageous to use a sphere with the thickest possible walls. The scientists favored pure aluminum for this. Aluminum has a relatively low flow stress and behaves particularly well when deformed under the effect of detonation pressure. Here the connection to the work of the research groups in Friedland should be sought.

Lithium-deuterium reactions were to play the role of "match" for the thermonuclear reactions. Schumann wrote: “This circumstance can be taken into account in a useful manner by simultaneously filling the pressure sphere to be used with heavy hydrogen with other light elements, for example lithium, beryllium, boron or light hydrogen in the form of chemical compounds on the inner wall the hollow sphere separated from the central space by thin layers. For example, the use of heavy lithium hydride (LiD) is recommended.«121

He called the ignition control principle developed by the Trinks group X-ignition. For preliminary tests, hollow spheres with a diameter of about one meter were used. The size of the bullet was explained by the problem of explosive placement. The simultaneity of the detonation of the explosive charges was more likely with a larger bullet than with a small one. The explosive device was to be detonated a few meters above the ground.

Summing up, Schumann commented on the group's experiments

Trinks states: "All the difficulties mentioned can be overcome technically and the effort required is relatively small and cannot be compared at all with the effort required to free up atomic energy using the processes known to date."122 Planck, Esau and other participants in the discussion were impressed by Schumann's explanations.123

However, it was not the HWA research group that was to carry out the first major experiment. This was reserved for the Navy. We can only guess why. The Navy's explosives physicists were as good as those of the HWA. But the Navy had a plus on the part of theoretical physicists. In addition, their research was flanked by the "High Pressure" working group.

The “High Pressure” working group met in Göttingen on September 25 and in Munich on October 9, among other places.124 The Navy researchers were the most represented. Participating from their side were among others: Buchmann, Haxel and Jordan. There were also experts from the TH Dresden and the PTR and of course Gerlach's Munich group. A special role was played by Dr. Berthold, the managing director of the Goettingen company Grona. In his company, forty highly qualified engineers and technicians worked on the production of high-pressure bodies with the highest priority level.125 Gerlach’s secretary Giesela Guderian-Fehlberg remembered sixty years later that she only had to transport a “secret command matter” once and I took the train from Berlin to Munich on October 9.126

First of all, the high-pressure work of the Navy, which had already been discussed in Göttingen, was discussed. None of this is found in the log, which is due to the high level of secrecy. The participants in the working group also discussed »Investigations on explosive devices that are under extreme pressure«. Individual questions were only logged after this point had been dealt with.

A nuclear weapon test was to take place on the island of Rügen just three days after the meeting in Munich. There may have been a test beforehand, but neither the exact location nor the time are known.12?

October 1944: A first nuclear weapon test on Rügen

A much-cited and controversial report on a German nuclear test comes from the Italian journalist and war correspondent for the Corriere della Sera, Luigi Romersa.128 Romersa not only maintained good relations with the German military during the war, but also knew a number of important scientists, for example Wernher von Braun and Otto Hahn. After the war he wrote a large series of articles about Braun, the space race between the USA and the USSR and the transfer of high technology from Germany.129 At the end of the 1950s he was even allowed to visit the secret missile development centers in the USA.

In 1944, Romersa was the right man for a high-tech job. Mussolini wanted proof of Hitler's grandiose pronouncements, which he considered to be his last hope. Romersa's story has been told several times; he himself wrote about it after the war. Hardly anyone believed him. Heiko Petermann got to the bottom of the matter and visited Romersa in Rome. There he met a vigorous elderly gentleman.

When he wanted to discuss with him the general reservations about his story, Romersa laughed: »I have lived by questions, answers and observations for most of my life. I know what I saw.« At that time we didn't know that the Italian state archives actually contained documents about his trip to Germany. These sources show that Mussolini summoned the war correspondent Luigi Romersa on October 1, 1944 and instructed him to travel to Germany.130 »He told me: I will give you two letters, one for Minister Goebbels and one for the Führer . You will go to Germany and try to see as much as possible so that I too can find out from an Italian source.'131 So Mussolini wanted a compatriot as a witness.

In Berlin, Romersa was immediately taken to Goebbels. The meeting should have taken place on October 6th. 'There I explained the purpose of my trip and I gave him Mussolini's letter. And I also told him that I still have a letter for Hitler with me, which I should hand over directly. He picked up the phone, called Ras-

tenburg, and they said I should come. He told me that I would see a totally new bomb explode, an extraordinary force that no one could resist. He told me that when it was finished, and Goebbels said it would be six to eight months [...] that the intention was to detonate this bomb in Russia.«132 On October 7, 1944, Goebbels made a note in his diary: 'The Duce's speech about new German weapons still has an effect on Italian public opinion. It goes so far that it is claimed that the Duce could talk about the Palazzo Venetia again on October 28th. This word in God's ear! The Duce will still have bad after-effects because of this speech."133 There is much to suggest that Goebbels indirectly referred to his first conversation with Romersa on October 6 or 7 at this point. The reference to the Duce speech can only have been made personally. In fact, Mussolini did not deliver a "retaliatory speech" at the end of October, but only on December 16, 1944 in the Lyric Theater in Milan.

Romersa was in Rastenburg just one day after the conversation with Goebbels. This raises the question of whether Hitler knew anything about the fusion bomb test. Romersa denied this during the talks in Rome, saying that Hitler had not said a word about this weapon. After visiting aircraft factories in Silesia and Bavaria, Romersa returned to Berlin on October 10th: »In the night from October 11th to 12th I was picked up by a military car and taken to the airfield and from there in the direction of the Baltic Sea to Peenemünde brought. The terrain was a small island. It was full of vegetation, trees, tall grass, bushes, it was a beautiful place. There were some concrete houses, they were supposed to be houses, really as targets to understand the effect. [...] I did not see how the bomb was set up. I found out afterwards.
She stood on stilts. Afterwards I found out that if a transportable bomb had been made, they would be able to drop it from an airplane. But the experiment that I attended took place on the ground.

I was taken to a concrete dugout by this colonel, a senior weapons development official. Who had

a thick glass viewing window, very, very thick, a large crystal capable of withstanding any explosion. I then waited until a certain point when I heard some sort of chime, and then a phone call came from the personnel preparing the blast. Then they said that we should now be careful because the bomb would explode in a few minutes. In fact, we then felt a real earthquake, so strong that it seemed to us that it had shifted this small shelter. We clearly saw a flash of light, a blazing light, and then a large wall of smoke appeared in front of us.« One has to imagine the situation of the observers. You have

seen the test of such a weapon for the first time. But what was that weapon? Romersa speaks no German, and the interpreter from the Ministry of Propaganda had been withdrawn for reasons of secrecy. Nevertheless, Romersa at least understood something: "The bomb was called the 'dismantling bomb' to me at the time, I was never given the name 'atomic bomb', although atomic fission was already known." Romersa and his companions had to count more than four after the

explosion wait hours. Around 4:00 p.m., soldiers came and led them across the site: “They also wore these protective suits against the radiation. What impressed us enormously was that the landscape had changed radically. A great many trees were splintered, as if some tremendous force had simply snapped them in half. Some of the sheep we saw lying there were downright charred, they looked like they had been turned over a fire. We went step by step, and then we saw, as I put it in writing at the time, that the landscape seemed to have changed profoundly. Small houses had stood here and there, but they had simply disappeared. They had become heaps of mortar and debris. And the closer you got to the site of the explosion, the more tragic the landscape looked.«

Unfortunately, Romersa did not identify the officer responsible for the test. There is much to suggest that it was Colonel Friedrich Geist. When Petermann showed Romersa a photo of Geist in December 2003, almost sixty years after the event, he said succinctly: "It could have been him."

There is another small but important indication of the correctness of Romersa's statement, he describes the weather: "It rained constantly. A light but persistent rain from a low sky with fibrous clouds.« A review for October 12, 1944 he gave that exactly this weather prevailed on the Baltic Sea coast.134

Back in Italy, Romersa telephoned Mussolini on October 29th. He was received for reporting on the same day:135 »His reaction was that of a new glimmer of hope – of course! Given the situation we were in.
Suddenly there were ways to turn the tables."136 He urged Romersa to give lectures about his experiences and to publish them in newspapers. Romersa then lectured in the province of Brescia in front of Mussolini supporters, among other places, and published an article in the Corriere della Sera on November 1 in which he reports on the VI and the V2 and announces "new and latest" weapons, built according to principles , "against which there is no known defense [...] they will be the weapons of the final battle".137

Mussolini also used Romersa's reports to prepare for his appearance on December 16 in Milan. It was his last public speech. First he referred to V1 and V2: "Many have believed that thanks to the use of these weapons - by simply pressing a button - the war could be ended at a stroke: But this belief in miracles is naive, if not negligent."138 Then he puts his listeners off: »The English know from bitter experience that these are not imaginary weapons, that others will follow the first, I can confirm that based on my knowledge.«139 Part of the speech was not published . There was no mention in the newspapers of his announcement of an imminent German attack on the Allied capitals. This will be carried out with "bombs and rockets of incredible power". The new bombs could "destroy an entire city in a single moment."140 In his last interview on April 22, 1945, which would go down in history as his political testament, Mussolini again spoke of the "wonder weapons" and was clear: »The famous destruction bombs (dissolution bombs) are almost ready.

Just a few days ago I was given extremely accurate news. Hitler probably does not want to deliver this terrible blow until he is absolutely certain that it will be decisive [...] It seems that there are three bombs - and with an amazing effect. The construction of each unit is terribly complicated and of long duration.'141 Sixty years after the events, proving a small-scale nuclear weapons test is extremely complicated. We'll discuss this in more detail later, using a better-documented test as an example. Since Romersa's report does not contain an exact location, we had to find the explosion area in the first place. After extensive research and many false leads, local journalists pointed out a suspicious area to us in the spring of 2003.142 The test area is believed to be on the narrow Bug peninsula on the island of Rügen. This is also supported by reports from residents of the small island of Hiddensee, which lies opposite the Bug peninsula.143 They heard a powerful detonation on October 12 and then saw a large cloud of dust rising over the Bug peninsula. We found further indirect confirmation of the Romersa report with the help of American aerial photos from the years 1944/45.144

An aerial photo from April 1944 shows a freshly cut swath, two structures and a tower-like building on the suspected area. There is a house to the south. A year later the tower is destroyed, the house damaged and the other buildings no longer exist. Part of the open space seems to have devastated. A depression can be seen in the middle of this area on the aerial photo from 1953. It is likely to have been there as early as 1945, but cannot be clearly identified on the aerial photo from April 1945, which is only of moderate quality. In any case, a comparison of the aerial photos from 1944/45 provides evidence that tests with destructive effects were taking place on the southern tip of the Bug Peninsula at this time.

The place was almost ideal for testing new bombs. A sparsely vegetated and sandy terrain surrounded by water. Apart from a post office, there were only naval facilities

on the Bug Peninsula. These facilities were located several kilometers from the test site.

After the war, the area was reforested. Today pine trees and shrubs grow there. The hollow is at the southern tip of the peninsula. All around is an area of about three hundred by three hundred meters that is only covered with grass. A few stunted pines stand in the clearing. To the west you will find wall-like mounds, in front of which are the remains of concrete bunkers that are partially covered by sand.

After the aerial photo analyzes had confirmed our suspicion, soil samples were taken and examined in the area of the trough by physicists from the Justus Liebig University in Giessen. Without wanting to go into the details of the analysis here, the most important results of the soil samples should be mentioned:145
The series of measurements show some anomalies, including values for cesium 137 that are up to five times higher than the zero sample. The investigations were made extremely difficult by the loose, heavily eroded soil. The area has undergone significant changes in recent decades. In this respect, only samples taken at a depth of at least two meters allowed the detection of increased cesium values.

Glazing found near the crater, which was analyzed by scientists from the Geological Faculty of Heidelberg University, was also revealing.
A stone was discovered with a perfectly preserved blade of grass and ear of corn melted under its glazed surface.
This can only happen through a flash of very high heat.

When describing a second test, I will go into more detail about the analysis of soil samples and the conclusions that can be drawn from them. At this point it should suffice: there was the naval group, which prepared new types of explosive tests in close cooperation with Gerlach. Her scientific advisors, Hou termans, Jordan and Haxel, were among the best physicists in the country.
The terrain on the bow was managed by the Navy.
Finally, the aerial photographs and Romersa's report speak for themselves. If one now takes the physical examination

Adding the results completes the picture: On October 12, 1944, a small nuclear weapon was tested on Rügen.

Gerlach's service calendar for October 11th to 13th leaves open whether he was present at the test. Otherwise he will surely have known the result. Around noon on October 23, Gerlach received a delegation from the MWA headed by Admiral Rhein.146 Buchmann and other scientists from his research group were also present. Geist and Thiessen also took part in the long conversation. There was probably only one reason why Rhein was with the head of his nuclear physics research department at Gerlach: the results of the October 12 test were being evaluated.

Hitler knew about Romersa's order, but never mentioned the new bomb to him. He attached great importance to the utmost secrecy.147 Just one day after the test on Rügen, the Commander-in-Chief of the Navy, Admiral Dönitz, came to the Führer's headquarters to report. The record says: "3 p.m. Fuhrer situation in the smallest circle. From the Navy only Ob. i.e. M. personally present. Subsequent lecture by the Ob. i.e. M. with the Führer (in private).'148 We do not know how long Doenitz spoke to Hitler and what he said to him. What is striking, however, is the temporal proximity to the test. In the evening there was a meal with Dönitz, Himmler, SS Group Leader Fegelein, State Councilor Johst and Obersturmbannfuhrer Grothmann. Speer was added later. We know from the history of the V-Weapons that in 1944 the SS leadership pushed massively into the armaments projects that were considered crucial to the war. This also happened with nuclear physics research. When exactly the course was set for this still needs to be clarified. However, it seems certain that the SS took over supervision of the further tests at the beginning of November.

3. The SS comes into play

Hans Kammler - Hitler's last hope

Hans Kammler had a doctorate in civil engineering and was a general in the Waffen SS. Himmler commissioned him to build underground factories. Later he controlled the most important high-tech projects of the declining empire. He embodied the type of Prussian officer. Tall, slim, blue eyes, dark blond hair and a distinctive face with an aquiline nose. A great organizational talent.149 Speer characterized him as follows: »Always capable of unexpected decisions [...] ruthless, cold calculator, fanatic in the pursuit of his goal, which he knew how to calculate carefully and unscrupulously [...] Soon rumors were circulating that Himmler was trying to establish Kammler as my successor. At the time, I liked Kammler’s matter-of-fact coolness, who was my partner in many tasks, my competitor in terms of his imagined position, and my reflection in many ways in terms of his career and working methods: He also came from a middle-class family, had a university degree, was through his Working in the construction trade had been discovered and had a quick career at Ge made offers that basically did not belong in his field.«150

Kammler's office group was involved in the construction of the gas chambers for the extermination camps and in the demolition of the Warsaw ghetto. Together with Himmler, Kammler visited the Birkenau extermination camp on July 17, 1942 and probably also attended the selections and the murders in the gas chambers attacked in Peenemunde, the future of V-

weapon production was discussed at the Führer's headquarters. There was a division of labor between the Ministry of Armament and the SS. Speer remained responsible for technical issues. The relocation of production underground and later manufacture by concentration camp prisoners

was assigned to Himmler.152 On September 1, 1943, Kammler was appointed »Special Representative of the Reichsfuhrer SS for the A4 program«.153 Development and production of the rockets were to be continued at three locations: the main plant (Mittelwerk) was to be housed in one Find a tunnel system near Nordhausen, the “Cement” development plant (southern plant) was to be built underground near Ebensee, about a hundred kilometers east of Salzburg, and the experimental series plant (eastern plant) above ground not far from the rocket test site near Bliszna in the General Government. Only the plans for the central plant were fully implemented.

The workers for the expansion of the subterranean production facility of the Mittelwerk came from the Buchenwald concentration camp, eighty kilometers away. The SS housed the prisoners in so-called sleeping tunnels under indescribable conditions. The construction detachments had the highest death rate of all concentration camp detachments. 'Don't worry about the deaths. Everything has to be finished as quickly as possible«, Kammler is said to have ordered.154 The prisoners suffered from malnutrition, beatings, cold and relentless work pressure. By March 1944 alone, almost three thousand prisoners had died in Dora, and the SS sent another three thousand exhausted slave laborers to the extermination camps.155 The concentration and Mittelwerk were nothing but a "criminal enterprise." The main people responsible for this were Kammler, Speer and other armaments managers.156

Speer was full of praise for Kammler and described the construction work as a "really unique achievement". The underground factory was unparalleled in Europe and "unsurpassed even by American standards." 157 Himmler was also enthusiastic about Kammler's achievement. In January 1944 he promoted him to SS group leader and lieutenant general of the Waffen-SS.158 After the failed assassination attempt on Hitler on July 20, 1944, Himmler also became commander of the reserve army and chief of army armaments; he had achieved his goal. He was feared in the HWA and they rushed to convert the Peenemünde army establishment into a privately organized company

Operational capability of the V2«.160 Initially, he was also to assume responsibility for the production of the V2. However, after Speer's protest, Himmler had to revise this decision.161 Kammler later became the operational commander of the V-weapons wear.

Although production of the A 4 had begun in December 1943, the rocket was not technically mature. During test firing in Bliszna, more than two-thirds of the rockets fired broke up in their last phase of flight. These “air separators” gave the designers a hard time. As the larger lower section of the missile shattered, its warhead hit the ground, penetrating deeply before exploding. This significantly reduced the explosive effect. Hitler lost patience. Since the A 4 was not yet operational, he relied on the flying bomb. On June 13, 1944, a week after the start of the Allied invasion, the bombardment of London with the V1 began. The output of the A4 was throttled in favor of the V1.162 The first fire blast failed miserably. Of the 63 positions reported ready to fire, only ten V1s left the catapult

systems. Four flying bombs fell to the ground immediately after launch. At the end of August, the V1 mission against London had to be discontinued. Therefore, Hitler's hopes were once again pinned on the A4. Their production was now running at full speed in the Mittelwerk.

From September 1944, Kammler was responsible for the rocket attacks on London, Paris and later on Antwerp, Brussels and a number of other cities. Their effects remained unclear as the Allies remained silent on the V2 attacks.

Himmler had a pronounced weakness for "wonder weapons." Projects that were rejected by the research leadership of the Army or the Air Force often ended up with the SS. Best-known examples of this were various projects with "death rays."163 Himmler put Kammler in charge for this as well. On January 31, 1945, he also became the "Special Representative of the Fuehrer for Radiation Weapons."164 However , Kammler paid little attention to the "death rays" because they had no military value and he had other tasks to solve.

Rockets as carriers of weapons of mass destruction

The heads of the HWA were trained artillery officers and saw rocket technology as the logical further development of their weapon type. The military was concerned with developing a new offensive weapon. As early as 1936, Walther Dornberger, the military head of the rocket program, had promised the Wehrmacht leadership a rocket that could propel a warhead weighing one ton twice as far as Krupp's famous "Paris gun" once could.

In the longer term, the missile was indeed a revolutionary weapon, but this was not true for conventionally armed ones. A few thousand of these would do little. Hitler recognized this and declared in August 1941: "If it were to be used, it would have to be possible to manufacture and fire hundreds of thousands of devices per year."165 Studies by the Peenemünde engineers and the Armament Office showed, however, that the plans, more than year to build were absurd. This would have consumed the material resources of the entire air armament.

With a small number of rockets, each with a ton of explosives, it was possible to achieve psychological effects, which Dornberger and his men admittedly overestimated, but there was no turning point in the war. It was therefore obvious that the military also considered the use of missiles as delivery vehicles for weapons of mass destruction.

In his widely circulated book »Wege zur Raumschifffahrt«, Hermann Oberth, the father of the space flight movement in Germany, also discussed the possibility of launching poison gas attacks against enemy cities with ICBMs.166 Loading rockets with poison gas was considered during the war and proved to be so but not very effective. Poison gas rockets would have had to detonate a few meters above the ground to have maximum effect. The V2 without a ground clearance fuze was ill-suited for this.

On the part of the nuclear physicists there were no signals that the uranium had gone beyond basic research. Therefore, until 1944, equipping the rockets with nuclear warheads was out of the question. Diebner taught the rocket

Engineers repeatedly reported on the status of work on the »uranium machine«.167 As a result of these briefings, plans for the construction of nuclear-powered aircraft and rockets were discussed. This was little more than speculation, even if research contracts had already been awarded.168 Long before a decision was made to mass produce the A4, the successor model had already been designed in Peenemünde. From the start, rocket engineers thought big. Chief engineer Rudolph Schubert was responsible for constructing the buildings of the research institute in Peenemünde. »That was already intended for later space travel [...] Since I was able to work quite generously financially – money was not an issue

–, I put something there with all the harassment.”169 Schubert's statements come from a conversation he had with Major General Boelsen and Major General Hoffmann shortly after his arrest and which was overheard by the American secret service. »I wasn't supposed to build this little A4 [...] I was supposed to build the thing for America [...] I had built halls that were 33 meters high [...] Those are the biggest halls that ever existed. They were about four times the size of the Anhalter Bahnhof in Berlin.«170 Even heavy air raids were unable to harm these colossuses of concrete and steel.

If Dornberger's account is to be believed, then Hitler saw the A4 only as the first step on the way to the production of much larger rockets. He called for the rocket's payload to be increased to ten tons and the monthly number to two thousand. Dornberger ventured an objection, knowing these goals were unattainable. Hitler reacted angrily: "But I want a devastating - devastating effect!"171

In June 1939, the proposal to increase the range of the A4 to five hundred kilometers with the help of wings was discussed for the first time. The project received the designation A9. Also before the start of the war, the rocket engineers discussed the idea of building a large rocket, which they initially referred to as a “hundred-ton device” and later as the A10.172 From the combination of both projects, Peenemün’s future project group came up with the plan to build one »Amerikarake-

te«. An A9 was to be deployed in the nose of an A10 and be capable of hitting targets over three thousand miles away. This could have reached the east coast of the USA, and that was probably the plan of the military. The idea of the "American rocket" reflected the self-image of the Peenemünde engineers and revealed the megalomania of the Third Reich. Hitler and those around him were fascinated by the idea of being able to strike at New York one day. A defense would have been practically impossible. But the A9/10 project overwhelmed the rocket engineers' technical capabilities. The demands on the steering system were extreme, the aerodynamics had not been clarified and the necessary materials had not yet been developed.

long-range missile plans

It was only when the military situation in the German Reich deteriorated dramatically that Hitler is said to have given the order to shorten the test period and to begin production of the A9/10 rocket as quickly as possible.173 In order to mass-produce operational long-range rockets, However, it required extensive development work and time-consuming tests. That would have taken years, not months. Wernher von Braun knew this. Nevertheless, he got involved with the "American missile". From the fall of 1944, the project ran at full speed.174 In order

not to be too dependent on the large group of rocket engineers led by Dornberger and Braun, the SS attempted to take over a rocket project started by the Luftwaffe.175 The project was tested by the The Rheinbote rocket built by the Rheinmetall-Borsig company in the Tucheler Heide, southwest of Danzig at the Heidelager military training area.176 In the fall of 1944, Lieutenant Colonel Tröller, the commander of the Operations Center for Army Artillery Division 709, and Kammler discussed the use of the » Rheinbote« as a carrier for an atomic payload.177 After the war, the American secret service OSS pursued these plans.178

Just a few names of those active in the Tucheler Heide

Scientists became known to the Americans. According to OSS, the head of the entire project was Professor Huetten. In fact, it should be senior engineer Dr. Hans H. Hueter, most recently director of the Karlshagen development plant under Wernher von Braun.179 A professor Niels is said to have manufactured "a few small atomic bombs weighing between 1 and 5 kg." OSS did not learn any more details. It is left to further research to shed more light on this.

Wernher von Braun, who was asked about the Tucheler Heide complex in mid-1947, confirmed that he had shown interest in the use of nuclear energy for rocket propulsion. However, this project was quickly dropped due to the lack of material.
In the final report, the deputy director of US military intelligence in Europe, E. Tilley, stated: »Von Braun would not admit that he ever planned to combine an atomic bomb with a guided missile. He only spoke to Werner Heisenberg about the possibility of using nuclear reactors to drive the V2. He added that this plan was dropped because Germany lacked the necessary material for it.«180 But that was only half the truth.

OSS received other information, and it was explosive.
From the alleged atomic laboratory in the Tucheler Heide, a highly secret cargo was taken to Verona in Italy in March 1945 in order to be shipped from there to Spain. Also included were four boxes containing forty to fifty small ampoules of a white liquid. The ampoules were labeled "U234", "U235" and "Plu" and bore a stamp of IG Farbenindustrie AG. The abbreviations suggest that it was nuclear material.181 Remains of the packaging with inscriptions were found in an Italian interim storage facility. However, there was no trace of the ampoules.

Tilley described the mysterious transport as follows: "It turned out that not only uranium samples were included, but also reports on atomic energy and possibly also on atomic bombs as well as guidance systems for guided missiles and documents."182 In addition to the cooperation with the Air Force and the Army pulled the

SS also started its own rocket project in the Skoda works in Bohemia. Little is known about this to date. Skoda was one of the world's largest armaments companies and specialized in the manufacture of all kinds of weapons and ammunition, including handguns, tanks, artillery pieces and aircraft.183 In a strategically safe area, the SS began to gain experience in the production of modern weapon systems.184 Special ones Priority was given to work on propulsion systems, miniature batteries and homing missiles. In addition, a medium-range rocket with a range of around 1800 km was developed under the type designation V101.185 It is not yet known exactly whether Skoda completely manufactured the V101 or whether the rocket was completely assembled elsewhere.

When it became apparent that the V-weapons test sites in Pomerania and on the Baltic Sea coast would soon be lost, Kammler make preparations to continue testing in Thuringia. Reliable information about this can only be found sparsely.186 On April 18, 1945, "Paris Presse" carried an article about "Hitler's last dream - the V4". The factories are said to have been near Erfurt: “Think of a V2, which is not that imprecise, but on the contrary has a high degree of accuracy. A huge projectile, fifteen to twenty meters long, with rocket propulsion like the V2, but which, unlike the V2, is guided from the ground using radio waves and which, during its flight, can report its position to the control center, since it has the corresponding ultra-modern broadcasting technology available. A weapon that alone would not have decided the war, but could undoubtedly have prolonged it.« At the Nuremberg trial of the

main war criminals, an American soldier described his impressions: »It was a large underground factory with heavy equipment. We saw some rockets there in various states of manufacture. The factory was near the Ohrdruf concentration camp that we had liberated.«187

A Soviet report mentions an underground factory of amazing proportions. It was in nine tunnels near Crawinkel. Their floor area was given as up to two hundred thousand square meters.188 Another of two Soviet

A report written by majors describes a V-weapons control post: »There [near Ohrdruf] there is an underground facility which, according to locals and employees of the commandant's office, is a command center for the V-2.

A more detailed explanation was not yet possible. The Americans had sent a group of seventeen men into the underground facility. They didn't return. For further investigation of the facility we need specialists with special equipment, including communications engineering, lighting and oxygen equipment.«189

The high point and end point of testing new rockets was the launching of a large rocket from the site of a munitions factory Rudisleben on March 16, 1945.190 There had already been several unsuccessful launch attempts. It is still unclear what type of rocket it was and where the rockets were manufactured. However, there is increasing evidence that an underground factory was located in the ridge southwest of Crawinkel. Aerial photo analyzes have shown strong camouflage measures as well as intensive construction activity and vehicle movements in this area in the spring of 1945.191 The spatial proximity to the

nuclear research groups von Gerlach and Diebner is too obvious to ignore a connection. However, the works are unlikely to have progressed past the stage of improvisation.

While the SS was attempting its own rocket project, in the autumn of 1944 a particularly adventurous project was taken up again in Peenemünde, which had been assessed as technically immature and therefore rejected in early summer – the development of a floating launching base for rockets.192 Chief engineer Wachter and engineer Teßmann were again responsible for these tests.

The project was later given the code name »Test Stand XII«.193 The plan was to have a submarine tow an A4 rocket in a float made especially for this purpose close to the target area. For launching the missile, the submarine should surface. In the critical time between surfacing and the launch of the missile, the submarine would have been extremely vulnerable. Nevertheless, the project should be

"ability" to be enforced. The declared goal was "to conduct disruption operations on long-range targets that justify the additional effort for strategic and political reasons."194 The project was only to be implemented by a very small group of reliable officers. The high degree of secrecy had a crucial reason - to create the conditions for rocket attacks against the American east coast.

All SS activities in the field of missile development in Pomerania, Bohemia and Thuringia, which are only briefly presented here, are to be seen in the context of operational planning against the USA. The name Speers also appears on various occasions in connection with these vague plans in Allied intelligence reports. Like no other, Speer was able to disguise his true role in the Nazi state. We should therefore not believe his protestations that he knew nothing about the latest weapons Speer was an extremely skilful tactician, especially with regard to the "wonder weapons".

In June 1942, after the big conference with the physicists, he could not act otherwise than assigning their work to basic research. He had received no signals that would have asked him otherwise. A good two years later things were different. Thanks to the research of the shaped charge experts, an unexpected way emerged to make nuclear energy usable for military purposes after all. Colonel Geist and Gerlach will have informed him about it. On December 19, 1944, Speer wrote to Gerlach: “However, I attach exceptional importance to research in the field of nuclear physics and am following your work with great expectations [...] You can count on my support to overcome difficulties, which would hinder the work, can be calculated at any time.«195

Those weren't empty phrases. The armaments minister was even more direct in a small group. A downright egregious statement by Speer was reported by his competitor for a time, the architect Hermann Giesler. He declared on oath that Speer told him in January 1945: "We only have to get through a year and then we'll have won the war." Speer justified his optimism with the development of a nuclear explosive

stoff and pointed to a matchbox: "A nuclear explosive the size of this box is capable of destroying all of New York."196 Speer's reference to the matchbox can only mean that he was informed about the fusion route.
More than a few grams of lithium deuterite were not needed for a nuclear fusion bomb. Ultimately, the research led to the production of a hydrogen bomb, the destructive effect of which the scientists had at least roughly calculated or at least guessed at.

Also because surprising progress had been made on the way to a nuclear shaped charge bomb, the fantasies of attacking the Allied capitals were revived at the end of 1944. Rockets loaded with weapons of mass destruction were to play a decisive role in this. Even a cool calculator like Speer did not evade these plans. In the end, all related activities never got beyond the experimental and planning stage: the conversion of submarines for missile use could no longer be completed, the long-range missiles were at best in an initial phase of testing, and two agents who possibly coordinating attacks against New York were arrested in December 1944 as part of a major FBI manhunt.197

The SS and nuclear physics

While Himmler had been trying to gain supremacy over the rocket project since early 1943, the SS only came into contact with nuclear physics research later. The main reason for this was Himmler's increase in power in the summer of 1944. His appointment as chief of army armaments and commander of the replacement army after July 20 was a humiliation of the army by Hitler.198 Himmler was thus also responsible for the HWA. He delegated his new tasks to General of the Waffen-SS Hans Jüttner, who headed the SS leadership main office, a kind of general staff of the Waffen-SS.

About the underground relocation of production facilities, Himm-

ler inform the Gauleiter of Württemberg and Baden and demanded support. SS-Obergruppenfuhrer Hossmann quoted Himmler in this letter: "The duration of the war cannot yet be foreseen, moreover this will not be the last war, and future wars will certainly not be opened by lengthy declarations, not even by approaches of air fleets, which can be recognized in good time. He [Himmler] is of the opinion that, as a result of advances in technology, explosive devices will suddenly appear whose effects and speed will put our latest retaliatory weapon explosives in the shade.«199 Therefore one should dig as deep as possible and strive for as much cover as possible .

At this point, Himmler probably had no clear ideas about these new "explosives," but the SD apparatus was at his disposal. From the beginning of 1944, the SD officers Helmut Fischer and Wilhelm Spengler repeatedly turned up at Gerlach and tried to get an impression of the status of the work "politically reliable". From their point of view, Schumann did significantly worse. They considered him “politically and ideologically questionable”. Leaving aside such subjective evaluations, what Spengler and Fischer heard about the progress of work on the Gerlach uranium project was hardly satisfactory. The SD men sounded the alarm and accused the Reich Research Council of not pursuing the project with the necessary vigour. The limited progress was sharply criticized in a report dated July 26, 1944.201 One result of the inventory was the defense research community initiated by Werner Osenberg, head of the Planning Office of the Reich Research Council, which remained largely ineffective.

At the same time, activities by the SS leadership began behind the scenes. Himmler distrusted the leadership of the Wehrmacht and the armaments ministry. He asked Speer how far the work of the uranium association had progressed. The question already contained criticism. The armaments minister replied on September 23, 1944 that the basis for research into nuclear physics was very

was small and could not be expanded since it was basic research that was of no direct use for warfare.202 Speer apparently wanted to keep the SS out of the project. Himmler was not satisfied with that. Allegedly unnoticed by Speer, the SS had long since begun to set up their own Technical Office (T-Amt). This office was subordinate to the SS leadership office. As was usual with the Army and Navy Weapons Office, the T-Amt had an FEP department and was supposed to promote research and development of new weapon systems.

The management of the T-Amt was assigned to Otto Schwab.203 The doctor of physics was considered a competent scientist and a Nazi loyal to the line. Himmler promoted him to major general in the Waffen SS in 1942. The most important research facility of the T-Amt was housed in the village of Glau, near Trebbin. One of their departments dealt with nuclear physics issues. Since when it existed, who worked there and what level the research reached can no longer be reconstructed due to a lack of documentation. The few files that have survived only show that Schwab's group had some uranium and also did research on heavy water. The T-Amt even tried, albeit in vain, to procure large quantities of heavy water from the Uranium Association.204 The T-Amt of the SS maintained connections to Schumann and Ohnesorge. Schwab received knowledge of important aspects of nuclear physics research through these channels.

By smuggling SS members into influential positions, Himmler was able to influence scientific research projects. The following SS ranks were represented at the top of the Reich Research Council: Brigade Commander Rudolf Mentzel and his deputy Standartenfuhrer Wolfram Sievers, who was also Managing Director of the SS Ahnenerbe and head of the Institute for Defense Research in Waischenfeld (Upper Franconia), Senior Group Commander Hans Jüttner and Brigade Commander Otto Schwab, the head of the SS T-office. In addition, there were high-ranking SS men on the research advisory boards of all weapons offices, such as the aforementioned electrical engineer Professor Karl Küpfmüller in the

On September 16, 1944, Jüttner from the SS Head Office summoned Schumann for consultation.205 The discussion therefore took place immediately before the important meeting of the shaped charge specialists in Gottow. Despite some differences and personal sensitivities, a counterweight to the Ministry of Armament emerged with the constellation SS – Reichspost – Reich Minister of Education. This also created a new, dangerous situation for Gerlach, who had previously tended to stick to Speer's people. The SS leadership wanted to see faster progress.

The armaments research of the SS should also be promoted by a systematization of the use of scientifically qualified concentration camp prisoners. The reason for this was the deportation of the Hungarian Jews. Himmler wanted to exploit the specialist knowledge of Jewish physicists, chemists and other scientists for the »time-consuming calculation of formulas, the development of individual constructions and also for basic research«.206 He commissioned the Institute for Military Scientific Purpose Research of the SS Ahnenerbe with the scientific implementation and the Economic Administration Main Office of the SS with the organizational implementation of this plan and appointed the consultant for natural sciences in the Reich Main Security Office, Helmut Fischer, as supervisor. It goes on to say: »After the question of accommodation has been settled and the skilled workers available have been reported, the work orders will be issued by the Ahnenerbe with the involvement of the Reich Research Council. The areas of work of the authorized representatives for high-frequency technology, for nuclear physics and for jet propulsion as well as Prof. Süss, Freiburg, should be gi

The Reich Research Council was informed of Himmler's plan. Walther Gerlach should comment on this. At the end of August 1944 he wrote to Sievers: "I welcome the endeavor to use the specialist knowledge of the scientists in the concentration camps for basic research, and in this spirit I have agreed with Dr. Gray spoken.«208 In the period that followed, the SS set up a mathematical institute in the Sachsenhausen concentration camp. Eighteen Jewish scientists worked there, strictly shielded from the other prisoners, on research assignments from the Reichsfuhrer SS, the Reich Research Council and the OKW

Calculations for the rocket program. Another command of inventors and engineers had already been set up in the Plaszow concentration camp.210 It was later transferred to Flossenbürg and also worked on behalf of the KWI for physical chemistry.

Individual inmates in the mathematician group apparently came into contact with shaped charge research. The electrical engineer Franz Germann, for example, had amazing internal knowledge.211 After the war he reported to the Soviet secret service that he had made two important inventions: a high-voltage generator and a speedometer for aircraft. Even more interesting to Soviet officers were Germann's assurances that he knew how to build an atomic bomb and launcher. They let him put his ideas down on paper. Germann wrote several reports and drawings. His “workshop drawing for the production of the hollow sphere for the atomic bomb” was astounding. The hollow sphere made of precious metal, "e.g. silver," should have a diameter of ten centimeters and be filled with deuterium. His drawings corresponded exactly to the drafts of hollow silver spheres used for the first experiments in Kummersdorf.

The question is where Germann got his knowledge from. A possible explanation is that he was involved in the manufacture of the spheres. Germann was unable to provide a plausible explanation for the functional mechanism of "his" deuterium bomb. As a specialist, he was brought to the Soviet Union in April 1946.212 His proposals and drawings were examined in Moscow. A month later, the physicist Kalashnikov commented.213 He classified the plans as worthless and unscientific. Germann invokes a new law of nature without being able to explain it. The idea of triggering nuclear reactions with the help of a hollow metal sphere is flawed and based on ignorance of the laws of physics. With that, Germann's draft atomic bomb was off the table.

This episode proves that the SS left no stone unturned in the final phase of the war to participate in the development of atomic bombs. There also seems to have been a rapprochement between the long-standing rivals Himmler and Speer on this issue.
Some Gauleiters were already rumoring about a new axis.214

The recovery of fissile materials by irradiation

As a reminder, Herbert Wagner of the Henschel company sent two of his engineers to Paris in the summer of 1941 to gather information about Joliot's cyclotron. Immediately following this visit, he came up with the plan that the Luftwaffe leadership should entrust his company with the construction of a cyclotron and a high-voltage system. At about the same time, a research group headed by Professor Bernhard Dirk senior was working on nuclear physics problems at the Aviation Research Institute.215 We do not know what became of this and other research commissioned by the Luftwaffe leadership. One thing is certain, the research management of the Luftwaffe remained interested in these problems.216 This was also shown by a large workshop convened by the German Academy for Aeronautical Research in Berlin on May 6, 1943, in which all leading scientists of the Uranium Association took part. However, reactor development remained the responsibility of the Uranium Association.

The Luftwaffe achieved a coup by hiring the Norwegian scientist Rolf Wideröe.217 It is no exaggeration to call him the father of particle accelerators. In the autumn of 1942 he had written an extensive article for the journal »Archiv für Elektrotechnik«.218 In it he presented a draft for the construction of a 100 MeV radiation transformer and even considered the construction of a 1000 MeV system to be feasible. Such a facility would have been equivalent to, and in some respects even superior to, a large cyclotron. Wideröe's study caused a stir in the armament ministry and the Reich Air Ministry. Although the research report had already been published, it was subsequently declared a "Secret Reich matter" because its concept offered the chance of an accelerator that was not only suitable for basic research, but also for the extraction of larger quantities of fissile material.219 Immediately after publication, Wideröe was visited in Oslo by several officers of the Reich Aviation Ministry. Two days later he was flown to Berlin. In the Reich Air Ministry he was informed about the plans of the Luftwaffe, betatrons

to build. He was given a central role as a designer.

Wideröe met Colonel Friedrich Geist from the Ministry of Armament several times in Berlin. In his memoirs he almost apologetically points out that apart from Geist he did not speak to any other senior officer about his research work. It wasn't necessary, for Geist was the key man running research at the Ministry of Armaments.

Together with Bruno Touschek, Wideröe built the first European betatron with a power of 15 MeV in Hamburg in 1944. On September 8, 1943, he applied for a patent entitled “Arrangement for initiating nuclear reactions”. The accelerator system described there should weigh at least 130 tons and have a radius of ten meters. This draft was immediately declared a »Secret Reich matter«.

It would take us too far to go into all the Luftwaffe's nuclear-related projects here. It should be noted here that the research management of the Luftwaffe dealt with partial aspects of the uranium project. Her main interest was the construction and use of particle accelerators. So far, these projects have mostly only been seen in connection with the idea of using X-rays against aircraft. However, it is also conceivable that their main interest was the construction and use of particle accelerators for the extraction of enriched material. Powerful neutron generators could be used to irradiate uranium and thorium. If such systems are run for many months, small amounts of fissile materials – such as plutonium and U233 – can be obtained in this way, or the reactivity of metallic U238 can be improved.220

There were only a few systems in the German Reich that were suitable for long-term material irradiation. This included the high-voltage system of the KWI for Physics, the »Lightning Tower«. When the high-voltage cascades discharged, large, bright flashes regularly occurred. This was an impressive spectacle, especially at night. The facility was converted into a neutron source in 1941/42. Heisenberg took a high-voltage tower with him when the institute was relocated to Hechingen in the fall of 19

others stayed in Berlin. However, it is unlikely that significant quantities of fissile materials were obtained by irradiation in Berlin or Hechingen. The performance parameters of this system were not sufficient for this, as were the high-voltage systems of the Reichspost at the Ardenne Institute and at the APS.221 Diebner

recognized early on that powerful accelerator systems were not only important for basic research. As early as 1940, he ordered a high-voltage system of five million volts from AEG. It had been in service since 1943 until it was damaged by an Allied air mine. The large system remained in Hennigsdorf for some time and was then moved to a safe place. However, we do not know where she came from.

It is conceivable that the AEG high-voltage system was used to irradiate uranium. Indirect references to this can be found in a Russian document, which talks about the fact that the Germans had irradiated the source material for the bomb.222 Did Gerlach repeatedly meet with representatives of AEG for this reason?

Interestingly enough, shortly before the war, the staff of the AEG High Voltage Institute was assigned to him.223 Let us also remember that the director of the AEG Research Institute, Carl Ramsauer, was one of the most ardent supporters of nuclear physics research and not only had basic research in mind had, but war-related projects.

Another trail leads to Lower Silesia, in the immediate vicinity of the gigantic, unfinished Führer headquarters "Rie se."224 The company Dynamit Nobel ran a mine and an ammunition factory near the village of Ludwigsdorf (today Ludkowice). In addition, next to the local Wenzeslaus colliery, there are imposing remains of an unknown technical facility. Concrete pillars about twelve meters high are arranged in a circle with a diameter of around 35 meters. A massive power line led to the center of the facility. Surprisingly, an examination of the concrete plaster showed that cobalt 60 can be found there, which is mainly formed as a result of a strong neutron impact on iron or nickel.225

Did Wideröe's large radiation transformer stand here, which he had designed for the Luftwaffe in 1943?226 Documents on the ob-

we did not find any project. Therefore, only a comparatively new special field of historical science, industrial archaeology, can bring further clarity in combination with physical measurements.

Thought games before the Ardennes offensive

On March 30, 1944, Colonel Hans-Ulrich Rudel was invited to Hitler's Obersalzberg. Rudel was one of the few officers who didn't mince his words when dealing with Hitler and presented the situation at the front unvarnished. Hitler held his most decorated officer in high esteem. He tried to convince him that the war was going to take a turn and told of the imminent V-weapon deployment. Its effect should not be overestimated at the moment, said Hitler. “But that is not so important now, because at the moment he [Hitler] only wants flawless rockets. Later, normal explosives would not come into consideration, as they are currently, but something else that is so powerful that the positive war decision will then be made at the latest. The development for this is already well advanced and final completion can be expected soon.«227

These statements indicate that in the spring of 1944 Hitler was at least roughly informed about the work on the development of new types of explosives. What took place later in October on Rügen was a test. In October, scientists were not ready to offer a working weapon. But Hitler needed working weapons, not prototypes. From mid-August 1944 he had been entertaining the idea of an offensive in the West. In addition to the military-strategic and political goals, the offensive was intended to save him time, which he wanted to use to complete the development of new weapons.228 The Ardennes offensive was to be Hitler's last big gamble. At the end of November he outlined his plan: Antwerp was to be conquered within eight to ten days. The entire enemy force was to be pushed north and south, and then a massive missile attack on London was to follow.229

In the run-up to the Ardennes offensive, there was said to have been at least one discussion at the Führer's headquarters about the use of new weapons. There are no logs. We are therefore dependent on the memoirs of those involved. As with most other memoirs, care must be taken in interpreting the statements presented. Nevertheless, they are quoted here because they show what vague ideas Hitler had about the possibility of building and using nuclear weapons. SS officer Otto Skorzeny, the head of special commando operations, asked Hitler about the rumors about new miracle weapons: "Rumours were circulating about developments and already existing fantastic and absolute weapons. [...] Spontaneously and of course without asking any questions, I spoke about the rumours, about artificial radioactivity and the possible use of it. 'Do you know, Skorzeny,' he told me, 'that the energy released by this artificial radioactivity, if used as a weapon, would mean the end of our planet? The consequences could be horrific. [...] No nation, no single group of civilized people can in good conscience assume this responsibility. You would eventually be destroyed by the retaliatory strike. Perhaps only the peoples of the deep Amazon or Sumatra would have a chance of surviving.'"230

Apart from the conversation with Skorzeny, Hitler is said to have commented on new bombs during one of his round tables in November 1944. According to a statement by Hitler's adjutant, Julius Schaub, the Reichspost had developed "uranium bombs the size of a small pumpkin." These were soon to go into series production "in an underground SS plant in the southern Harz region."231 If the information is correct, only the central building "Dora" could have been meant. Doubts are warranted, especially since Henry Picker reproduced Schaub's statements only in indirect speech.232 Rochus Misch, one of the telephone operators at the Führer's headquarters, remembered that one of the adjutants reported at the end of 1944 of a conversation between Hitler and Ohnesorge, in which course the use of "uranium bombs" was discussed. There is said to have been talk of seven such bombs. However, Hitler did

refused to use this weapon because he feared a terrible revenge from the Allies. They would "fifteen thousand bombers ver collect and kill all of Germany with poison gas«.233

It is therefore not true that Hitler saw the atomic bomb as a weapon of the more distant future.234 Contemporary historians like to put forward this argument with reference to Speer's communication from the summer of 1942, according to which the Uranium Association was concentrating on basic research for the development of a uranium machine. This overlooks the fact that Hitler's statements in 1944/45 did not refer to the research of the Uranium Association at all, but that he knew about new "powerful explosives" and their state of development.

Rumor has it that the Allied secret services also learned about new German weapons. The American OSS received worrying information in November 1944. An intermediary reported that an officers' conference had taken place in Stockerau, Austria, at the beginning of October 1944, at which a National Socialist commanding officer had spoken about the imminent use of new types of bombs. The officer said they would soon be ready to go into series production of the new weapon.

As soon as the front in the west could be stabilized, a larger number of the new bombs should be used: "The atomic bomb will destroy all life within a few hundred meters of the point of its impact. " tactical nuclear weapons have been spoken.

In any case, a weapon comparable to the later American atomic bombs was not intended. How the OSS reacted to the report, whether it was classified as credible and forwarded, is unknown.

In the autumn of 1944, "Hitler's bomb" was still in the experimental stage. Hitler's instinctive rejection of the use of a nuclear weapon sprang from a realistic calculation. A few such bombs were of limited military value. Their use would have further escalated the war and likely prompted the Allies to resort to massive retaliation using poison gas and biological weapons. Nevertheless, Hitler had certain hopes of being able to use the new bomb in a few months. In the combination

This weapon with a rocket was the real danger for the Allies.

The Ardennes offensive began on December 16, 1944, using all conceivable reserves. After some initial successes, the offensive got bogged down shortly after Christmas. Hitler's Luftwaffe adjutant, Nicolaus von Below, found him deeply depressed after the failure of the offensive. He spoke of taking his own life and said to Below: "I know the war is lost. The superiority is too great. I have been betrayed." Then Hitler regained consciousness and continued: "We will not capitulate, ever. We can go under But we will take a world with us.'236 On New Year's Day 1945 the German radio stations broadcast a speech by Hitler. He was unable to set accents that gave rise to hope. He did not mention any new "wonder weapons".

Was Goebbels better informed? He spoke to propaganda officers on January 5, 1945.237 He explained: “Gentlemen, what matters is that the German Wehrmacht keeps the enemy away from the heart of the Reich for six months, then the latest weapon we have at our disposal will be used come, and in 24 hours this war will be decided with Germany's victory.«238 Only days later Speer used similar formulations in a private conversation.239

Schumann and Trinks are slowed down

After a test had already taken place in the north under the direction of the Navy, the scientists at the HWA also wanted to get a chance. However, they were suddenly stopped. At the end of 1944, the Ministry of Armament forbade them to continue their experiments.240 The forces were to be pooled under the leadership of the SS. At the beginning of 1945, the weapons offices of the army, navy and air force were to be merged. However, this reform came much too late and was not implemented.

Schumann had long since looked for alternative locations in Dolgelin and the surrounding area with his Second Physics Institute, if only to avoid bombing raids on the capital. He had

not only patrons in the leadership of the HWA and in the SS. His critics, above all the SD officers Fischer and Spengler, blamed him for the failure with the production of the N substance. This warfare agent had been praised by Schumann as a miracle weapon, but it turned out to be extremely problematic in its handling.241

At the end of September, Spengler wrote to Osenberg: »Prof. Schumann is neither suitable as a scientist nor as an authorized representative [for explosives physics]. The Reichsfuhrer SS spoke out clearly against him. He is considered questionable from a political and ideological point of view, but he should be rejected in terms of character.«242 Since the SS leadership mistrusted Schumann and voices were also raised against him in the HWA, he was no longer to be involved in the further development of nuclear hollow charges.

The armaments ministry formally initiated the research stop for Schumann's group. This decision was difficult for Trinks to understand. He thought he was on the right track. Almost obsessively, he continued his calculations. Even after the end of the war, in the seclusion of the Bavarian Forest, the problem of the nuclear shaped charge would not let him go. The world around him had collapsed, but he spent many hours a day doing his calculations sitting on a pile of wood. Did he know about the other group's successful attempts and was he now looking for the theoretical solution? He later said to his son: "We weren't far from the atomic bomb."243 Schumann too remained optimistic for a long time. He remarked to Volkswirt Erwin Respondek that the problem of the uranium bomb had been solved: »The bomb was to be dropped on a

parachute. The ignition device was solved in a technically simple form [...] Prof. Schumann said at the same time that it had not yet been possible to bring the uranium to explosive spontaneous decay.«244 This meant that the fusion worked, the fission small ner amounts of enriched material but not yet?

Respondek couldn't know what exactly Schumann was talking about. Therefore the Americans could not do much with his report either. We now know that Schumann did not mean a Hiroshima-type bomb when he spoke of the "uranium bomb," but the Trinks type

developed thermonuclear shaped charge bomb. What is interesting about his description is the reference to the planned drop by parachute.

It wasn't just around Schumann's people that things became quiet. The naval group also seems to have been stopped. In any case, we have no evidence that she performed any further testing. Apparently, the SS leadership only wanted to rely on Gerlach and Diebner. Gerlach had to report to Himmler in person at the end of 1944.245 He was to carry out the next test with a group of handpicked employees. Looking back, Gerlach said that he had secretly hoped for a negotiated solution with the Allies. But now he found himself in the role of the sorcerer's apprentice.

Gerlach's diary gives an important clue to the possible construction of the bomb. Hidden on a back page, it contains several sketches that are incomprehensible to the layperson. They show spheres, lenses and half shells with one or more focal points.246 In addition to these sketches there are formulas for thermonuclear reactions. Only these reveal what Gerlach was thinking about when he put the drawing to paper.

Gerlach's sketch of a hollow body resembling an egg is also instructive. Reflection lines of the energy transport are drawn in it. Now we know from the flow researchers Busemann and Guderley that the generation of energy can be significantly increased with a Cartesian oval. In very simplified terms, this corresponds to the principle of the whispering gallery. It has the shape of an elongated ellipsoid of revolution. If a person stands in such a whispering gallery, another person who is far away, in the other focal point, can understand whispered words well. This effect is explained by a well-known law of acoustics, according to which sound waves emanating from one focal point meet again at the second.
This effect, which was investigated by the flow researchers, was later used to detonate the hydrogen bomb.247 Modern nuclear weapons mainly function according to this principle.248

Gerlach has also already outlined ignition by means of half-shells and an internal gap or fusion material through to cascade ignition. Of course, sketches are not construction plans and should not be overrated.

FOURTH PART

March 1945: Nuclear weapons tests in Thuringia

1. The test

Final preparations

In the shadow of the relocation of headquarters, research facilities and industrial companies, the SS had begun to prepare the Ohrdruf military training area for a special weapons test. There must have been agreements between Gerlach or Diebner and the SS leadership about this. How this happened in detail is not documented. Decades later, Himmler's adjutant, Werner Grothmann, recalled that at the end of 1944 Gerlach and also Diebner reported to the Reichsfuhrer SS several times: "At Himmler's request, it was arranged that e.g. B. 'Heinrich' [Himmler's special train] had to stop somewhere for two hours on a trip, and then Osenberg came along. It was the same with Gerlach. I saw that myself too. Incidentally, Diebner also met Himmler several times in this way.”[1] On

November 2, 1944, Himmler, accompanied by Kammler and Colonel Gustav Streve, who had been appointed by the OKW as Kammler’s representative for the construction of a new Führer Headquarters, visited the Ohrdruf military training area.[2] He visited the SIII construction site, which had just started – that was the code name for a large complex of tunnels in the Jonas Valley, which was officially intended to serve as the Führer’s headquarters, but possibly also to house technical facilities.[3] Finally , there was a discussion between Himmler and Kammler. After this trip, Himmler spoke optimistically to his personal physician: “We will soon be using our last secret weapon. And that will lead to a completely different war situa

The SS was entrusted with the logistical preparations for the tests, and Kammler must have been the one in charge amazed by the selection of the test area.

To the south, five hundred meters away, the Tambuch begins, a larger closed forest area. The terrain rises to the west and thus forms a good privacy screen in the direction of Ohrdruf. Likewise to the north, where a plateau forms a natural barrier about a kilometer away. Ultimately, however, it was not the privacy screen that was decisive. The terrain was only suitable for testing a weapon with a comparatively limited radius of action.

Things were not progressing well until the spring of 1945. The bomb construction was probably not yet complete or there were problems with the ignition mechanism. In any case, after his meeting with Himmler in mid-November, Kammler hurried back to the Baltic Sea coast to take part in test firing of the Rheinbote rocket.6 In addition, Kammler had evidently begun earlier to concentrate rocket development and production in Thuringia. In addition, the research group was relocated from Diebner to Stadtilm and other groups of scientists from the TH Berlin, the PTR and the Reichspost to Ilmenau, Gehlberg and Gehren. Scientists from the »Ahnenerbe«, which Himmler had also had expanded into a scientific development center for the SS, came directly to Ohrdruf Preparation of the test site near Ohrdruf and the work of the scientists in Stadtilm up to date

kept.8

The SS also took care of the procurement of rare materials for the physicists. Thus, at the beginning of February 1945, Colonel Dr. Schröder-Stranz in the armaments ministry and demanded that the head of the raw materials office hand over all the radium.9 He produced a letter from Himmler authorizing him. In the raw material office they played for time. Nothing was given to him. A few days later, Schröder-Stranz showed up again at the armaments ministry and asked for tantalum wire. The employees of the raw materials office suspected that these procurement actions were related to nuclear research, because tantalum is a

rare metal and has an extremely high melting point, similar to tungsten. It is therefore preferred for the construction of nuclear weapon fuses. It is unclear whether the SS needed this material for the bomb or for their own development.

Among the many problems in making nuclear weapons was the development of the initiators, tiny sources of neutrons inside the bombs that start the chain reaction. In research and for laboratory experiments, radium beryllium sources were used for this. But the scientists were looking for a better solution. Polonium was well suited.10 It is almost free of interfering gamma rays and is very important for many nuclear conversion studies. A polonium initiator is barely larger than a hazelnut. A tiny amount of polonium combined with beryllium was able to release about 95 million neutrons per second. Little is known about the fact that a plant for the production of polonium was located at the PTR sidings in Ronneburg. This facility was unique in the world, as the head of the PTR's nuclear physics department, Carl-Friedrich Weiss, remarked with pride.11 On February 28, 1945, Gerlach and Diebner were in Berlin for the last time. From there they drove to Ronneburg in the afternoon.

When they arrived around 3 p.m., Gerlach asked Dr. Weiss has the entire supply of polonium and the high-powered neutron source. The PTR scientists did not find out what the polonium was used for: »During the visits, he [Gerlach] did not talk to me [Weiss] about the original inquiries, especially since we were not alone. Violations of secrecy were subject to the most severe penalties; no one was allowed to learn more than was absolutely necessary.”12 Gerlach and Diebner arrived in Stadtilm that evening with the valuable material. The General Secretary of the KWG, Ernst Telschow, also joined them there.

From mid-December 1944, Gerlach sought to appoint the scientific director of the Navy's nuclear research group, Otto Haxel, to his leadership.13 Admiral Rhein, however, showed little inclination to accede to Gerlach's request. So Gerlach made further advances.14 Osenberg finally reacted on March 10 and submitted a decision to the OKW and the naval command.

application for admission for Haxel.15 At this time, however, he was already in Stadtilm. Many years later, Professor Ernst Stuhlinger, who was involved in secret work at the beginning of the uranium project and who came to Peenemünde in the spring of 1943, reported that he had met Haxel in Stadtilm. He lived with scientists from the Diebner group in the middle school.16 Similar to Stadtilm, there were alternative centers in Ilmenau, just a few kilometers away. Several young physicists turned up there in the final weeks of the war, all of whom came from TH Berlin and had worked with Haxel. These included Helmut Volz, Luise Schützmeister, Erika Leimert and Dr. Hirt.17 Volz had "disappeared" from the TH Berlin since the summer of 1944 and had been working in Erlangen, as one of his then students remembers.18 The role that Haxel's group played in preparing the test cannot be said for lack of sources.

In addition to the scientists from the TH Berlin, a group of technicians from the high-voltage institute of AEG Gerlach and Diebner was also subordinated.19 From the few files that have survived, it is not clear whether the AEG group was also relocated to Stadt ilm. But the very fact of working together is revealing. In 1943, AEG wanted to put a 5 million volt high-voltage system into operation in the Berlin exhibition halls, but had to drop this plan because of the Allied air raids. We don't know what happened to the high-voltage system afterwards. Now Professor Biermanns and his people suddenly appear at Diebner's.

First of all, Gerlach's path is to be followed further. Two days before he left Berlin for Stadtilm, he met Paul Rosbaud, the editor of the journal Naturwissenschaften. Gerlach did not know that Rosbaud worked for the British secret service under the alias »Griffin« .20 He valued Rosbaud and had met with him frequently. Gerlach made a depressed impression on Rosbaud on January 29, 1945.21 It seemed as if he wanted to say goodbye forever. Gerlach feared he would lose control of the "heavy stuff," uranium and heavy water. Apparently he was afraid of the SS.

Rosbaud was horrified at the thought that the material, which he said was only made "for use in a horrendous war machine against the civilized world," might yet have been blown up by "a few fanatical Nazis" 22 could become. It remains unclear what he meant by a "terrible war machine." How did he even think of that? Was Rosbaud possibly passing off Gerlach's words as his own to protect him?

Rosbaud asked what Heisenberg intended to do with the material. Gerlach answered curtly: "Perhaps business."23 Rosbaud knew nothing about the progress of the Diebner group, and he also had only a vague knowledge of the work of the Uranium Association.

On January 31, 1945, Gerlach, Diebner and Wirtz left Berlin for Stadtilm, together with the materials from the KWI for Physics and Gottow. There, Diebner's group was meanwhile also working on questions of radiation protection.24 Gerlach applied to the agricultural office in Weimar for a food allowance for his scientists. The reasoning is interesting: »During experiments with new types of radiation, alarming changes in the blood count were observed recently, which were undoubtedly caused by these high levels of radiation [...] You will understand that I have to do everything I can to prevent those with these dangerous To protect gentlemen who work with radiation as well as possible.«25

The preparations for the reactor tests in Stadtilm were no longer particularly intensive. The hectic activities of Gerlach, Haxel and Diebner stood in strange contrast to the inadequate preparation of the reactor tests at school. Their hectic pace only becomes understandable when you consider that they wanted to carry out experiments of a completely different kind.

There is only one eyewitness report from the 1960s about the work of the Diebner group in Stadtilm. During their research, the officers of the state security came across stories about death marches of prisoners, hidden art treasures, old SS rope teams and mysterious weapon tests in the last months of the war. The master plumber Gerhard Rundnagel, who worked for the Diebner group, made interesting statements

had worked: »I had mainly worked with Dr. Rehbein and Engineer Rackwitz, with whom I developed a kind of trusting relationship.

So it was on July 7th, no on July 9th [1944], when Dr. Rehbein said: 'Rundnagel, now listen to the news very carefully, within a few days you will hear a decisive report that will determine how the war ends.' [...] On July 20th the assassination attempt was over Hitler. When I asked Rehbein whether that was what he meant, he just laughed and said: 'Now it's no longer used, the war is lost.' I often talked to him about what was actually being done here; because it really didn't look like work. Then he told me that something was being developed here that had greater

explosive power than anything I could imagine as an old pioneer. A single bomb could destroy all life within a radius of twenty kilometers, even if it were a hundred thousand people. I replied that that was nonsense, that he couldn't fool me, an old soldier, that wasn't possible. I really do know a little bit about explosives. Rehbein just smiled and said the whole bomb was only a few centimeters tall but weighed around eight kilos. When I asked him if I could see the thing, he waved me off: 'It could cost us both our heads.'" The state security officers also noted in their interrogation protocol that, according to Rundnagel, there were two safes in the school's basement stood. A large sum of money was kept in one, and "two atomic bombs" in the other

26

Rundnagel's report should be read critically. His times cannot be correct. Nevertheless, his statements contain remarkable information. The official exchange of letters shows that the alternative post was not set up until the end of September 1944.

Rundnagel's reference to the assassination attempt on July 20 is therefore wrong. The information about the destructive effect of the bombs should also not be overinterpreted. We don't know whether the scientists were talking about "their" bomb or whether they had future developments in mind.

Nevertheless, Rundnagel's description is an important source. The physicists Rehbein and Berkei, the round nail during his interrogation

also mentioned, as well as the technician Rackwitz belonged to Diebner's closest circle of employees. They apparently gave hints about their work on a nuclear weapon, the size (about eight kilograms) and the radius of destruction (twenty kilometers) pointing to considerations for the construction of an atomic bomb. We thus have something like a self-representation of Stadtilm's works, even if only at second hand.

On March 2nd, Gerlach received a visit from two experts in Stadtilm members of the PTR, Professor Kußmann and Dr. Hess.28 Kussmann had been employed at the Physikalisch-Technische Reichsanstalt since 1925 and headed the magnetics laboratory. From 1938 to 1945 Hess was a scientific employee at the PTR in the laboratory for X-ray spectroscopy.29 Was it a routine visit or were the last details of the construction discussed in Stadtilm, possibly the questions of magnetically triggered compression? We have to assume that the preparations for the test were almost complete. Gerlach had scheduled a work meeting for March 3 around noon. Nothing more can be found in his service calendar for that day.30 But we know what happened ten hours later.

Nuclear weapon test in Ohrdruf

The preparations for the nuclear weapons tests did not go unnoticed in Arnstadt and on the military training area. Some officers must have heard from the scientists or from Kammler's entourage that a new weapon was about to be tested and wanted to observe it. Two vantage points offered a good view: the clipper buildings in the middle of the military compound and the Wachsenburg, about two miles away as the crow flies. On the evening of March 3, Clare Werner and a relative watched the military training area from the picturesque, medieval castle.31 She had heard from officers that "something that would change the world" was happening tonight. A few days earlier she had happened to see the preparations while out walking.

Years later she described what happened in March 1945 and

First recorded in 1962.32 When Heiko Petermann interviewed Ms. Werner in September 1999 in Arnstadt, she was well aware that in the past she had not been believed. Nevertheless, she repeated her story and first described what she had observed during the walk: »It was a large frame. It was surrounded by wood, wooden beams and some metal. There was something in the middle, you weren't allowed to get close.'33 Somewhere on the northern edge of the training

ground, at a safe distance from the terrain of the 'triangle', as this section was called near the village of Rohrensee, gathered on the evening of March 3rd 1945 a small group of SS officers and civilians. Among them probably Kammler, Gerlach and Diebner.

There are no minutes, but there are statements by witnesses, so that what happened can be reconstructed: At around 9:20 p.m., a bright flash of light, reddish on the inside and yellow on the outside, illuminated the landscape. Clare Werner: »I was standing at the window of the south wing of the so-called residential wing, and all of a sudden we saw a tall, slender column rising into the air, and it was so bright [...] we could have read a newspaper at the window. And this pillar enlarged at the top, and looked like a great tree in leaf. We also felt tired the next day and we were still tired days after. We had no idea what it could have been.«34 The observers

at the Wachsenburg felt a strong draft. After that everything was quiet. Days later, residents of the surrounding communities complained of nosebleeds, headaches and nausea, which Heinz Wachsmut also reported.

In 1944/45 he worked for the Brüx shaft construction company in Ohrdruf and Bittstädt. He knew nothing of the events described, but he remembered the next day: "In the afternoon, the SS drove up in trucks, the SS actually had nothing to say to us, since we always worked with special orders, which always had the stamp of the Reichspost or the Research Council and had to be destroyed immediately after reading. It was an order signed by Kammler. We had to load up all the wood that was available. The trip went to Rohrensee, there were a few ther

SS doctors worked because a large number of residents had headaches and were spitting up blood. We were wrong there and were immediately taken to Gut Ringhofen near Mühlberg. We were told there that we had to erect piles of wood at the edge of the forest, about twelve by twelve meters and only a maximum of one meter high. We had to wear full protection, including our prisoners. At the edge of the forest we saw a few heaps of dead people who were probably former prisoners. All of the people had absolutely no hair, some parts of their clothing were missing, but some of them also had skin blisters, blisters of fire, bare raw flesh, and some (body) parts were no longer there. SS and prisoners brought the bodi

When we had finished the first six heaps, the corpses were placed on top, about fifty per heap, and [then] a fire was set. We were driven back. In the estate we had to take off our protection and our clothes. This was also immediately set on fire by the SS, we had to wash and were given new clothes and protection, plus a bottle of schnapps each, including our prisoners.

A senior SS officer told me that yesterday there was a big flash of fire up there, something new was being tried out, the whole world will be talking about it, and we Germans are the first. Unfortunately, some things didn't go as planned, and now there are a few less useless people.

During the second operation, three more heaps were erected. Then we saw some completely disfigured creatures crawling out of the forest. Probably some couldn't see anymore. I can't even describe it today. About twelve to fifteen people were immediately shot by two SS men.

[...] They had to be carried by other prisoners to the piles of flames.

We were brought back to the estate and everything repeated itself. Around 11 p.m. we drove back to Polte 2. Fourteen fireplaces could be seen at the edge of the forest. We couldn't eat anything that day or the next, there was always schnapps for us and the prisoners. One of our prisoners told us that he still understood one of the half-dead: [...] 'Big lightning - fire, many dead immediately, gone from the earth, simply no longer there, many with large

burns, many blind. Greetings to mother from Oleg Barto to Guryev.‹«35 An important detail is the location of the cremation site. The Commander-in-Chief of the Allied troops in Europe, General Eisenhower, the Commander-in-Chief of the 12th Army Group, General Bradley, General Patton and two of his commanding generals visited the remains of the Ohrdruf concentration camp on April 12, 1945. The picture presented to the American officers was shocking even for these experienced soldiers.

A camera team recorded the impressions. One of the pictures shows Generals Eisenhower and Bradley in front of an open crematorium on the Hainberg, a small hill north of the concentration camp. They stand near the edge of a forest and look at a mountain of charred body parts and scraps of clothing lying on iron rails. At the end of April, American officers wrote a report: "These (previously stored in a barracks of the north camp) Corpses were stacked in piles of 250 before being cremated. Two kilometers from there (northern camp) a ditch about two hundred feet long, five feet wide and three feet deep contained fragments of seven to eight thousand calcined corpses. A number of those bodies were still open."36 What Eisenhower, Bradley, and Patton couldn't know was that the site they visited on April 12, 1945, might also have been victims of the April 3 nuclear weapons test just a month earlier. burned in March.

But let us return to the statement of Wachsmut. In principle, his descriptions agree with the report of a top-class spy who, a few days after the test, briefed the Soviet military intelligence (GRU) in detail on what was happening in Thuringia. He spoke of numerous prisoners of war and SS men who had been killed.37 It is also worth noting that Kammler personally ordered the corpses to be burned and the men wore protective clothing. It is not clear how many people died in the test. If we take as a basis the nine cremation sites mentioned, later expanded to fourteen cremation sites with fifty dead each, then one must assume a number between 450 and 700 dead. Had the SS

used the inmates as human guinea pigs? Or was it an accident?

In black ice and snow, Gerlach, Diebner and Telschow drove at 6 a.m. on March 4 in the morning to the Heisenberg Group in Haigerloch. While Gerlach was only in Haigerloch for one night and then traveled on to Munich, Diebner stayed there until March 10.38 Nothing was learned in Haigerloch about the dramatic event in Thuringia.

Diebner was back in Thuringia on March 12th for a second test. Clare Werner remembers: “It was around 10:15 p.m. on March 12, 1945. It wasn't as bright as the first time. We didn't have any nosebleeds, etc. There was an air-raid alert at 9 p.m. for the towns and for us.«39 The second test was obviously less effective.

One thing is certain: in March 1945 at least one nuclear test was carried out with the aim of developing a weapon.

Stalin is informed

The scientific director of the Soviet nuclear project, Igor Kurchatov, was regularly summoned to the Kremlin in 1945. There he was presented with espionage material compiled by the Scientific and Technical Department of the NKVD.40 The secret information was only available to him and occasionally to a few other nuclear physicists at his institute.

Soviet agents had already infiltrated the British nuclear project in 1941 and had had several top-class informants in Los Alamos by the summer of 1944 at the latest.41 All in all, a former Soviet intelligence general estimated that Kurchatov had more than ten thousand sheets of information from Los Alamos available.42 Based on these documents, Kurchatov knew that the Americans were about to test an atomic bomb for the first time. Kurchatov's folder on German nuclear physics, on the other hand, contained only a few sheets.

On March 28, Kurchatov had a detailed plan of the future

gene scientific and technical work for the Soviet nuclear project.43 This amounted to copying the American development. The ink under Kurchatov's grand scheme was hardly dry when Lieutenant General Ivan I.

Iljitshov, Chief of Military Intelligence (GRU), two explosive espionage reports from Germany.44 The first report was dated November 15, 1944 and the second March 23, 1945.

The first report was of preparations for testing a new one Weapon, which ran under the control of the SS: "The Germans are in the process of testing a new secret weapon with a large destroy ing power to perform. Test explosions are being prepared in Thuringia under the strictest secrecy.«45 The informant from the GRU did not yet know Bomb's structure construction any details of the bomb design at that time, nor did he know when the test was to take place. Iljitshov drew the following conclusion in November 1944: »In the last few months our sources have repeatedly reported on the attempts of the Germans to always test weapons and means for their purpose. Presumably these experiments represent an attempt by the Germans feverish to carry out tests with an atomic bomb, the existence of which we have only incomplete stronger information about it.«46 [Underlining in the transport original]

Gaps

liable information

The second letter was far more worrying. Iljitshov compiled the information on March 23, 1945, just a few days after the tests.47 He wrote: "Recently the Germans in Thuringia have carried out two large explosions. They took place in a wooded area in the strictest secrecy.

From the center of the explosion trees were felled to a distance. For the from five hundred to six hundred meters experiments were destroyed. erected in fortifications and buildings found perished, often leaving no prisoner of war genes, the explosion center trace of them. Other POWs who were some distance from the center of the explosion sustained burns to their face and body, the degree of which depended on the distance from the center [...] The bomb contained It was transported on a specially designed flat wagon. With her ver probably U235 and has a weight of two tons. a

tanks of liquid oxygen were brought together. The bomb was permanently guarded by twenty SS men with dogs.

The bomb blast was accompanied by a powerful detonation wave and the development of high temperatures. A strong one was also observed radioactive effect. The bomb represents a sphere with a diameter of 130 centimeters.«48

Kurchatov was undoubtedly surprised when he read this report. Did the Germans actually manage to detonate a nuclear weapon? He could not completely rule out targeted disinformation. On the other hand, Lieutenant General Ivan I. Iljitshov had deemed his source reliable. Stalin, Molotov, politically responsible for the Soviet nuclear project, and Chief of General Staff Antonov had already received the reports. Kurchatov had to give an opinion.

Again, Iljitshov had drawn a brief conclusion at the end of his report: "Without a doubt, the Germans are conducting tests of a bomb with great destructive power. In the case of successful tests of their further production of such bombs in sufficient quantities, they will have a weapon the of our open in location is sive to slow down.«.[49]

After the war ended, the Soviets got their hands on a film about the explosion. The archive inventory says literally: "Film about the launch of a V2 and the explosion of an atomic bomb." The film was archived together with a large number of documents about German rocket technology in May 1946.50 Unfortunately, this stock is still not available for scientific use to this day accessible.

For the time being, we remain dependent on the evaluation of written reports and the descriptions of eyewitnesses. The reports were apparently not written by a nuclear physicist. The informant could not know some of the details that were crucial for the physicist, or reported them incompletely. This made the task difficult for Kurchatov. While he described the design description as "very credible," he was "not entirely convinced that the Germans actually attempted an atomic bomb."51 According to his calculations,

According to the calculations that had entered the work plan just two days earlier, the detonation of a nuclear bomb should have destroyed an area of several square kilometers and not just a few hundred square meters. Nevertheless, he recognized or at least suspected that the Germans were working on a new type of process: "Here we are talking more about specific details at the beginning of the explosion process, which are based on some new physical factors in the impact of neutrons on the atomic nuclei of the uranium ."52

Kurtchatov had to make a serious decision. Should he classify the reports as hoaxes? He didn't have much time to think. He knew that his answer was of the utmost importance, perhaps even for the further course of the war. He proved to be a prudent tactician. The war would be over in a few weeks. After all, the Red Army was already at the gates of Berlin. On the other hand, he couldn't downplay the danger. It was Kurchatov's duty and life insurance to warn the dictator about the new threat. Finally, on March 30, 1945, he wrote a carefully considered statement. He passed these on to Stalin or Molotov. The only copy went to the head of the Main Military Intelligence Directorate, Lieutenant General Ivan I. Ilyitshov.

Kurchatov emphasized the importance of the report from Germany presented to him, spoke of "very credible design descriptions" and asked for further information: "It would be extremely important to receive more detailed and more precise information on these questions. It would be even more important to find out details about the process of extracting uranium 235 from natural uranium.«53 With that he had cleverly covered himself up. He left the next step to the Head Office for Military Intelligence, which was to provide him with additional material.

One point deserves special mention in connection with the GRU reports - the fierce competition between the Soviet authorities. GRU, which reports to the administration of the Red Army's General Staff, did not disclose its findings on the core tests in Germany to the NKVD. Even Stalin and Molotov apparently saw no reason to

to inaugurate Chief Beria. This led to the grotesque situation that Beria, who took over the management of the Soviet nuclear project on August 20, 1945, was probably unaware of what was happening in Thuringia. How else can one explain that his people, who interrogated dozens of German scientists in the summer/autumn of 1945, including some from Diebner's group, did not ask about the tests in Thuringia and who was responsible for them?

Who informed Soviet military intelligence about the tests? From the texts at least some conclusions about his background are possible. It couldn't have been a nuclear physicist, otherwise the functional mechanism of the bomb would have been described more precisely and the names of the scientists involved might also have been named. The exact test area was also unknown to him. He spoke only very generally of Thuringia. On the other hand, the man had a very good knowledge of the part played by the SS in the preparation of the experiments. It can therefore be assumed that he was in contact with the highest ranks of the SS or belonged to them himself.

After the war, Schumann suspected that Thiessen had updated the Soviets on the latest German atomic secrets. He directly linked the first Soviet nuclear test in August 1949 to the adoption of the basic hydrogen bomb design developed by Walter Trinks.54 Schumann was wrong on this point. However, it cannot be ruled out that information from Thiessen's environment reached Moscow during the war. In March 1945, for example, Thiessen held talks with representatives of a communist resistance group, the subject of which was not only his acceptance into the communist party, but also the handing over of research documents from the War Economics Office.55 The roles of Armament Minister Speer and Colonel also remain to be clarified Spirit. The latter met with Gerlach and Graue in Berlin on March 23, the day the second GRU report was written. Did the information come from this circle?

Speer compiled a detailed report on the change in American bombing tactics and the damage in the future Soviet occupation area.56 In mid-March 1945 he sent this report to the diplomat Julius Schnurre, who was in

stayed in Stockholm. Schnurre, who had worked at the German embassy in Moscow from 1939 to 1941, had the relevant channels at his disposal. On behalf of Speer, Schnurre handed the report to the Soviet embassy with the request that it be forwarded to Stalin as quickly as possible. The motive for Speer's action remains in the dark. He himself gave no explanation for this. The question is obvious: was this the only report that reached Moscow via Schnurre?

»Distinct nuclear reactions with energy release«

So what are the written sources about the tests in March 1945: a report written immediately after the events by a high-ranking German source of knowledge for the Soviet military intelligence service GRU, submitted to Kurchatov on March 28, as mentioned, and two in the 1960s written eyewitness accounts. There are also reports about the test preparations. These include the descriptions by Gerhard Rundnagel and Horst Kirfes. The latter reported in Soviet captivity on the relocation of nuclear researchers together with the finished bombs from Berlin at the beginning of 1945.57 The indications of nosebleeds, headaches and nausea among the inhabitants of the surrounding communities also point to a nuclear event. The dust thrown up by the test explosion contained radioactive fission products, which spread out after the explosion. These were responsible for the symptoms described. The same phenomena were later found in other nuclear weapons tests.58

Of course, Heiko Petermann and I visited the Ohrdruf military training area, which is still in use today, to find the site of the bomb's explosion. We initially focused on a trough about 45 meters wide. As on Rügen, scientists from Professor Scharmann's working group took numerous soil samples.

First of all, proving a nuclear weapon test sixty years later is difficult. The radiation has long since subsided. The misconception of large-scale radioactive contamination is dominant in public. Such views have been

particularly widespread after the Chernobyl reactor accident in 1986. But Chernobyl cannot be compared to Ohrdruf. Relatively small amounts were used in the Thuringian tests, whereas large amounts of fission products were released over a longer period of time in the reactor accident. If one uses the use of the atomic bomb in Hiroshima as a reference value, one has to assume that the energy released was about a thousand times larger. Nevertheless, it is not easy to prove the atomic explosion of August 6, 1945 in Hiroshima today. The city is not "radiated" but currently has radiation levels below the natural radiation levels of the surrounding area. This has to do with the relatively rapid decay of the residual nuclear radiation, which after fourteen days is only one thousandth of the original value and then continues to decrease. It is therefore not to be expected that the result of a core test that took place sixty years ago can still be found today. From the outset, the analyzes could only start with anomalies and isotope vectors.

In a first step, soil samples of more than one kilogram each were taken at a depth of up to forty centimeters at three positions on the inner and outer edge of the depression and at four locations up to 450 meters from the center and evaluated. Particles that had melted at very high temperatures were found in the samples using special sedimentation processes. Even with the help of simple measuring instruments, increased radioactivity could be detected in these. Laboratory tests of the particles followed.

A key part of the analysis was gamma spectrometry, with several samples showing caesium-137 levels three to four times the national average.59 Elevated levels of Cs137 are considered to be indicative of nuclear fallout. We had this important finding checked by scientists from the Physikalisch-Technische Bundesanstalt (PTB). The PTB in Braunschweig has the best measuring devices and sophisticated analysis methods. Professor Uwe Keyser, head of the “Experimental Research Focus” department, confirmed the results of his colleagues in Giessen and went into more depth with the analyses.

In addition to Cs137 , cobalt 60 was detected in one or more samples both by the Gießen group and by PTB. As a rule, this isotope is only produced by the action of neutrons on iron or nickel and is considered a decisive indicator of a high neutron flux.

In and of itself, this doesn't say much. After the Chernobyl reactor accident, much higher values were measured in numerous places. However, the cesium found in Ohrdruf did not come from the reactor accident. As in criminology, there are "fingerprints" in radiation physics, and the ones available to our experts clearly deviated from the Chernobyl pattern.

The third analysis step involved alpha spectrometry. prof Keyser confirmed a disproportionately high proportion of fission products: “There is a wide spectrum of enriched material that is not caused by a natural source. Some of the isotope anomalies are drastic and do not match any known individual event. Chernobyl can be ruled out as the cause of the fission products.«60 It must be emphasized once again that the values measured in absolute numbers are sometimes at the limit of detectability and only allow statements to be made as a whole. Only the presence of fission products and uranium is important. Their concentration or degree of enrichment cannot be absolute. Professor Walter Seifritz, an internationally recognized expert in the field of nuclear explosive devices, used the following comparison to clarify the U235 and U238 isotopes found: "It's like a bathtub: if you have a certain amount of hot water in it and a If you add a different amount of cold water, you get an average temperature.«61 Knowing all the evidence and measurement results – the increased cesium-137 and cobalt-60 activity, the detection of U238 and U235, the particles from a process of High-temperature melt – the scientists we consulted came to the conclusion that there are traces of a nuclear event in Ohrdruf.62 Professor Brandt: »The essence of this event is

that during the explosion there were also clear nuclear reactions with the release of energy.«63

The combination of all the facts, the statements of the GRU informant, of Wachsmut, Werner, Kirfes and Rundnagel, the activities of the physicists around Gerlach in Stadtilm, the reactions in Moscow to the news about the tests and the measurement results, underlines the assessment: In At least one small nuclear weapon test was carried out in Thuringia in March 1945. However, this test was not comparable to the American test of June 1945. The German scientists did not have a sufficient amount of fissile material. So you must have used a different route.

While the analyzes were still going on at the various institutes, our expert for aerial photo analysis, Matthias Muckel from the company Mull & Partner in Hanover, which specializes in identifying and clearing military contamination, pointed out a suspected area about eight hundred meters south-west of the first investigation area. 64 On a reconnaissance flight in June 1945, the US Air Force took a large series of aerial photographs of the Ohrdruf area. A bulge with a diameter of about fifty meters appears in one of the images. A very sharply contoured crater around twenty meters in diameter must have formed at the same time. On an aerial photo from the end of 1944, nothing was visible at this point. No samples could be taken there due to the risk of duds.

Another seemingly insignificant detail caught our attention when analyzing the aerial photographs: the test area of all places was extensively mowed in the spring of 1945. This is most unusual. No other part of the military training area was taken care of in this way. According to Matthias Muckel, the purpose of the mowing was to cover up tracks and make aerial reconnaissance more difficult.

How did this new evidence tally with samples taken hundreds of meters away? We must have taken the samples in the radioactive fallout area. Even in an experiment with a subcritical quantity, fission products are formed which are distributed in different concentrations and degrees of enrichment in the environment. Starting from the

prevailing wind direction, the radioactive fallout took place in the direction of Bittstädt. A zero sample, taken about one kilometer to the west, was at the level of background radiation officially specified for Thuringia for all relevant isotopes.

What type of bomb was it?

After the expert opinions supported the thesis that the tests described by the contemporary witnesses were actually nuclear weapons tests, it was necessary to find out what was being tested. This brings us to a particularly difficult question, the construction of the bomb. There are basically dozens of ways to do this.65 The details cannot be reconstructed in all details. This would require the scientists' original documents and test descriptions, which are no longer preserved. Nevertheless, we can draw conclusions based on the available documents and measurement data and try to show what we think is the most plausible way.

Possible explanations were:
a) a "reactor bomb" or a "dirty bomb" b) a nuclear fission bomb c) a nuclear fusion bomb or a combination of nuclear fission and fusion bombs.

The idea of the reactor bomb had existed in the Uranium Association since 1940. For example, the fission products obtained from the reactor could have been distributed using conventional explosive devices.66 Some theoretical preliminary considerations speak in favor of the thesis, but all documents related to the tests speak against it. We also consider the test of a "dirty bomb" whose effect is based on the release of radiological substances with which a larger area can be contaminated to be unlikely. If such a bomb had exploded, radium, strontium and other highly radioactive substances would have been dispersed, for which there is no evidence.

We suspect the origins of the construction in the work of the shaped charge specialists of the HWA, the Navy and the Air Force

fen academy. We know from Erich Schumann that by the end of 1944 he considered the problem of starting a thermonuclear reaction to be solved in principle. The ignition guidance principle developed by Trinks' group should be able to trigger such a reaction. The material question was solved.

However, a design description attached to the GRU report of March 23, 1945 did not really fit our theory. The GRU informant knew a possible blueprint, but no blueprint. He the was overwhelmed with the explanation of how the bomb worked. We can safely assume that there were several construction plans. The Schumann/Trinks group alone had conceived half a dozen arrangements.

Nevertheless, it had to be clarified whether a bomb constructed according to his descriptions could theoretically work at all.67 The following design elements are mentioned: a high-voltage discharge tube that drew its current from generators, a sphere made of metallic U235, retarders, a protective box with a cadmium layer, more common Explosives, detonation devices and a steel jacket.

Below we attempt a reconstruction of the bomb, which cannot be more than an approximation based on the historical sources and the information provided by leading nuclear physicists:

At the center was a spherical cadmium-coated aluminum protective case. The cadmium served as a neutron brake. A sphere or half shell made of metallic uranium and the initiator were placed in the container. The high-voltage discharge tube was supposed to produce a stream of fast neutrons that would start the chain reaction in the fissile material. (The use of a high-voltage discharge tube for the generation of fast neutrons was perhaps not an ideal solution at the time, but it was possible in principle. This principle can also be found in American design descriptions of implosion bombs and fusion-enhanced nuclear weapons from the 1950s and later.68 However, we think it more likely that in the German bomb that was actually detonated, a polonium-beryllium source was used as the initiator. This was the best known neutron source at the time. The Americans also used it during construction

their first atomic bombs polonium-beryllium sources.) A number of explosive lenses were to be fixed on top of the cadmium layer. Two electric detonators (detonators) must have belonged to each of these explosive lenses. The structure, containing numerous small explosive charges, was covered with a light aluminum alloy protective shell and a steel outer shell. The spherical bomb is said to have had a diameter of 1.30 meters. This agrees with the descriptions from Anklam and Friedland.69 In the small towns of Mecklenburg, aluminum balls were tested by the Lindemayer research group. Years later, bystanders were still wondering what the V-weapons researchers were doing with the large aluminum balls. The statement made by Ms. Ingeborg Brandt, who was conscripted into the Lindemayer Group, is worth remembering once again: »There was a kind of terrace in front of our hall. This is called the test stand. There was a ball there. I myself estimate it to be 1.80 meters in diameter.«70 The GRU reporter estimated the weight of the entire construction at around two tons. This statement agrees with that of Schumann, which brings us to a crucial point.71 The synchronous detonation of the explosive charges was intended to compact the uranium sphere and activate the neutron source. The neutron stream it triggered should act on the fissile material. The explosive charges that exploded acted like "a center-directed strike" that brought the U235 "above critical mass." Today one would say that the material was compressed.72

As described, an atomic bomb could actually have worked. This design description was available to several physicists, who all confirmed that the unknown author had pointed out a practicable way.73 However , we were not able to obtain any clarity as to whether the design mentioned in the report actually corresponded to the bombs tested in March 1945. The most important question is the type and amount of fissile and/or fusion materials used.

In the first part of the agent's report it is said that the bomb "is probably equipped with U235". As we have seen, one of the biggest problems for German scientists was